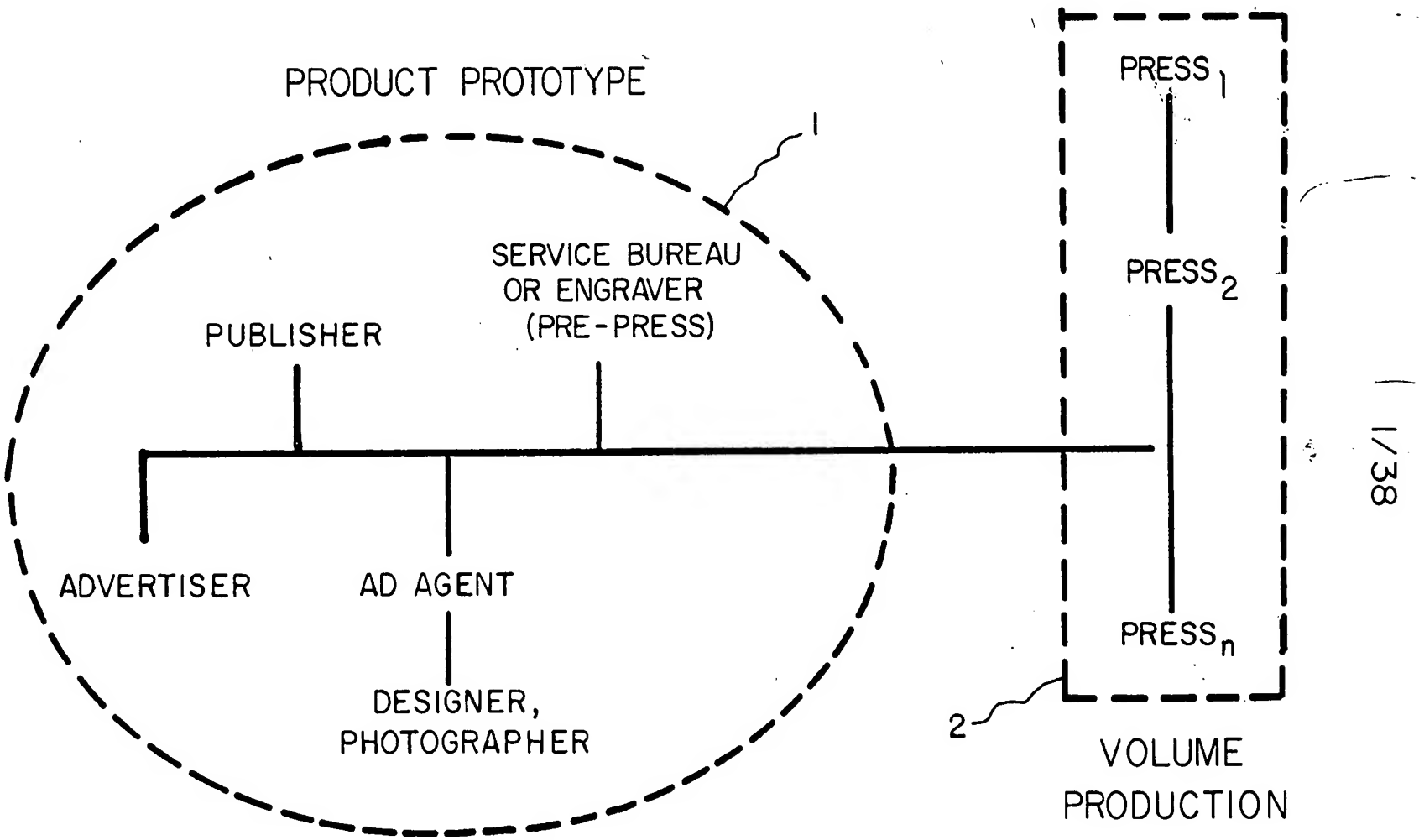

PRODUCT PROTOTYPE
1
SERVICE BUREAU
OR ENGRAVER
(PRE-PRESS)
PUBLISHER
ADVERTISER
AD AGENT
DESIGNER,
PHOTOGRAPHER
PRESS 1
PRESS 2
PRESS n
2
VOLUME
PRODUCTION

FIG. 1

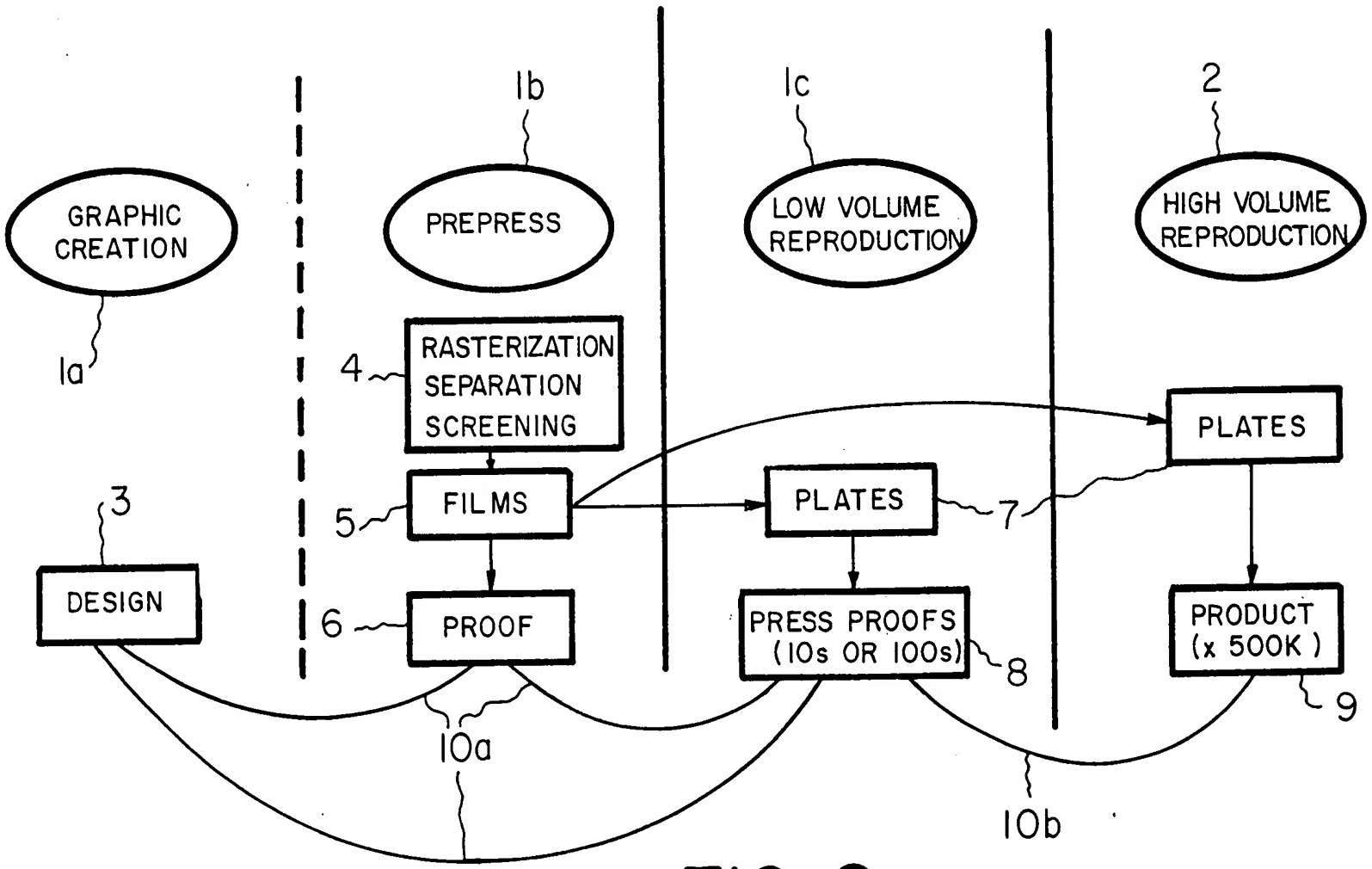


FIG. 2

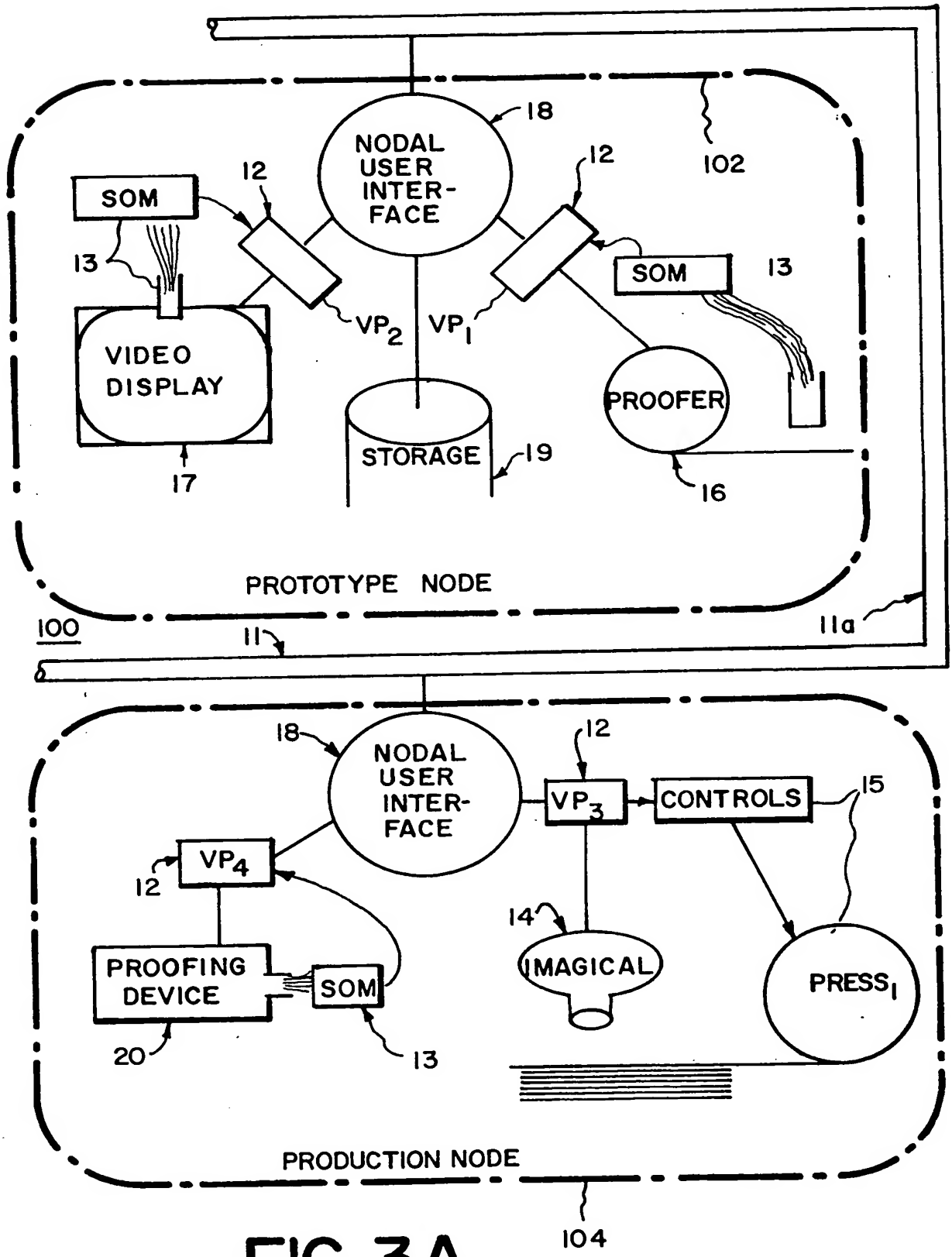

NODAL USER INTER-FACE
18
102
12
12
SOM
13
SOM
13
VP2
VP1
VIDEO DISPLAY
17
STORAGE
19
PROOFER
16
PROTOTYPE NODE
100
11
11a
NODAL USER INTER-FACE
18
12
VP3
CONTROLS
15
VP4
12
14
PROOFING DEVICE
SOM
IMAGICAL
PRESS1
20
13
PRODUCTION NODE
104

FIG. 3A

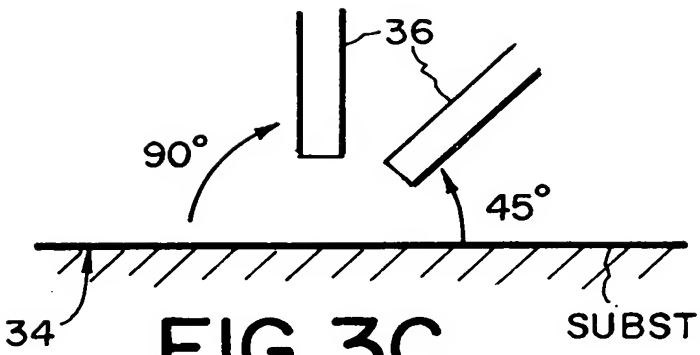


FIG. 3C

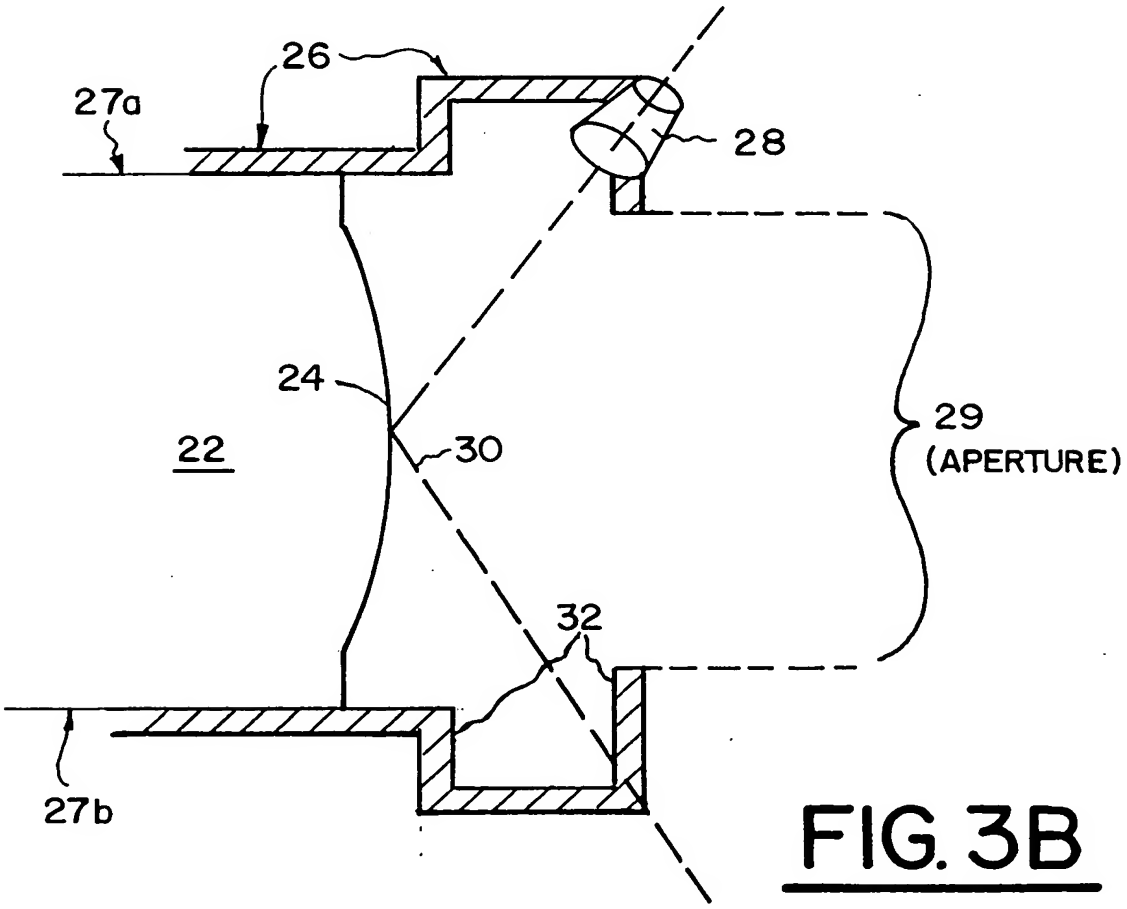


FIG. 3B

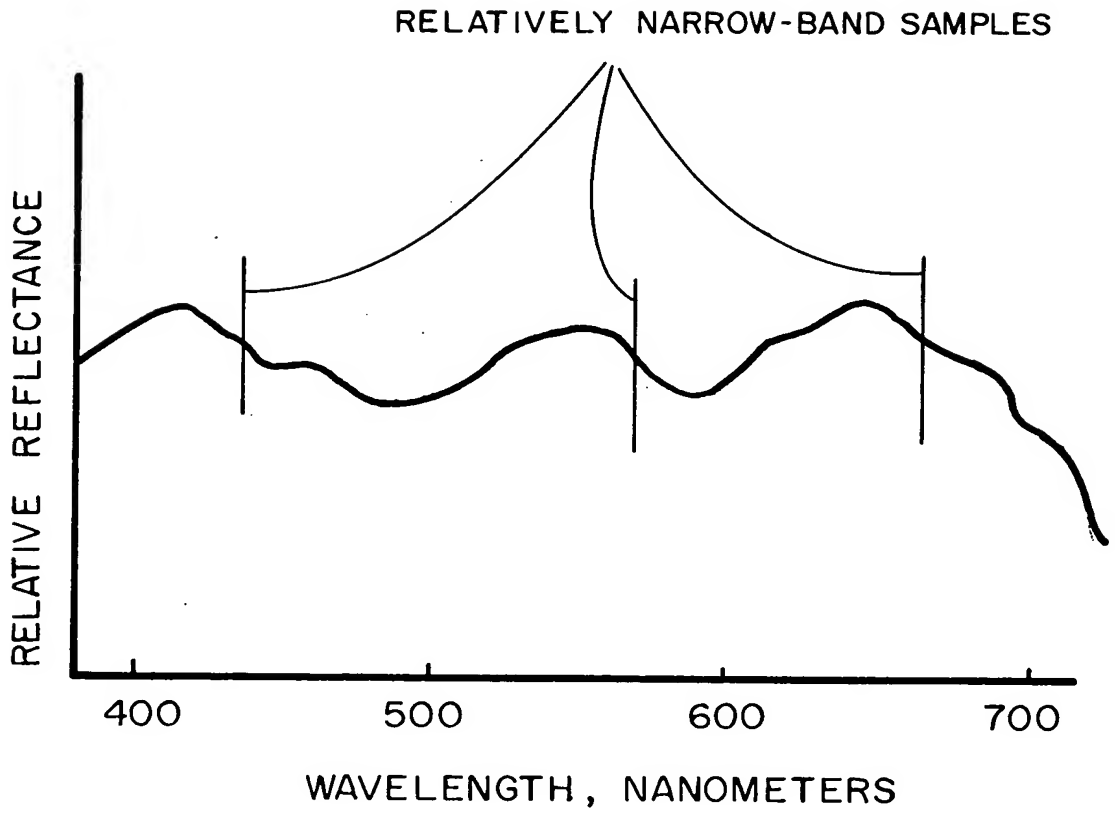

RELATIVELY NARROW-BAND SAMPLES
RELATIVE REFLECTANCE
400
500
600
700
WAVELENGTH, NANOMETERS

FIG. 3D

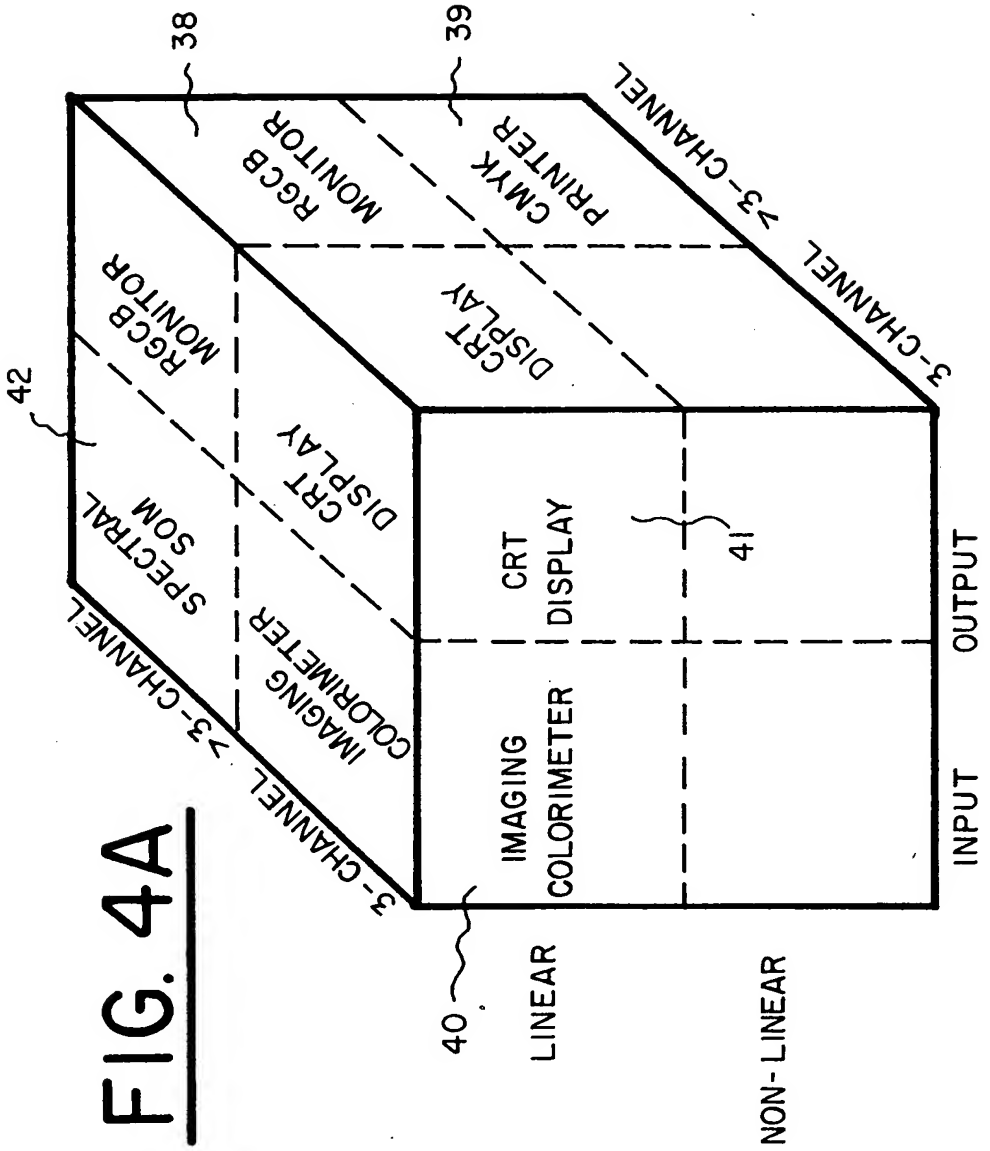

38
39
3-CHANNEL
73-CHANNEL
RGCB MONITOR
CMYK PRINTER
CRT DISPLAY
RGCB MONITOR
42
CRT DISPLAY
SPECTRAL SOM
IMAGING COLORIMETER
3-CHANNEL
73-CHANNEL
CRT DISPLAY
41
IMAGING COLORIMETER
INPUT
OUTPUT
40
LINEAR
NON-LINEAR

FIG. 4A

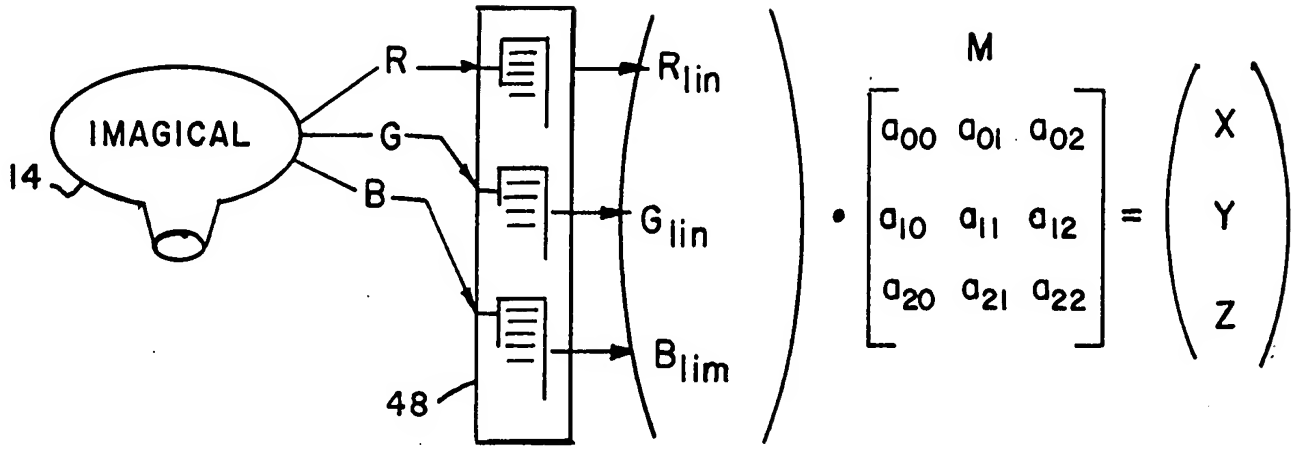

IMAGICAL
14
R
G
B
48
R_{lin}
G_{lin}
B_{lim}
M
a_{00} a_{01} a_{02}
a_{10} a_{11} a_{12}
a_{20} a_{21} a_{22}
X
Y
Z

FIG. 4B

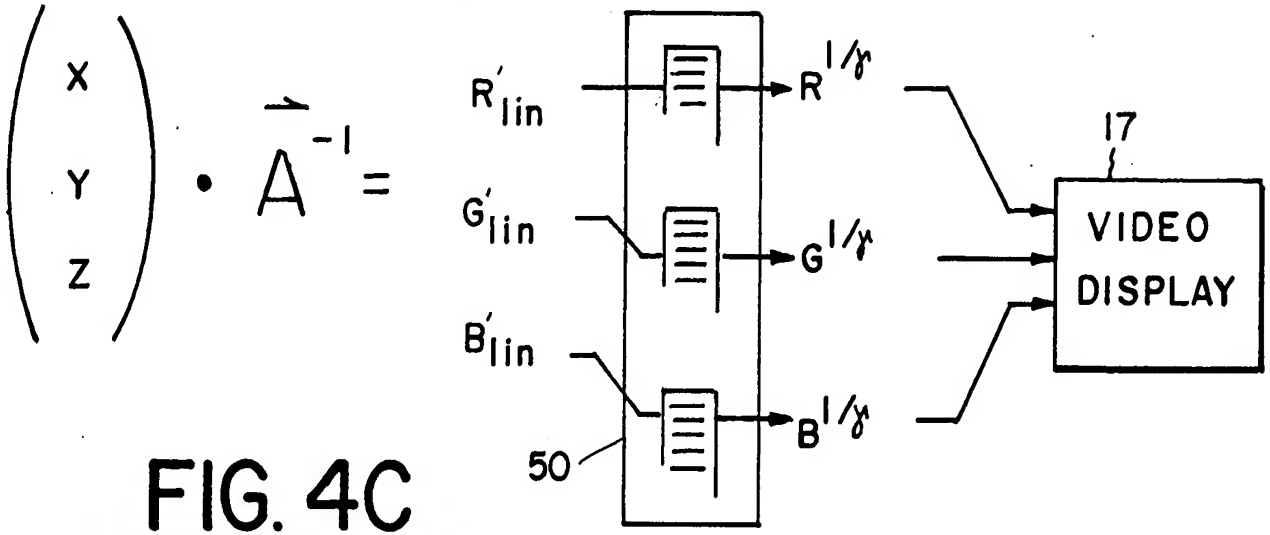

X
Y
Z
$\vec{A}^{-1}$ =
R'_{lin}
G'_{lin}
B'_{lin}
50
$R^{1/\gamma}$
$G^{1/\gamma}$
$B^{1/\gamma}$
17
VIDEO
DISPLAY

FIG. 4C

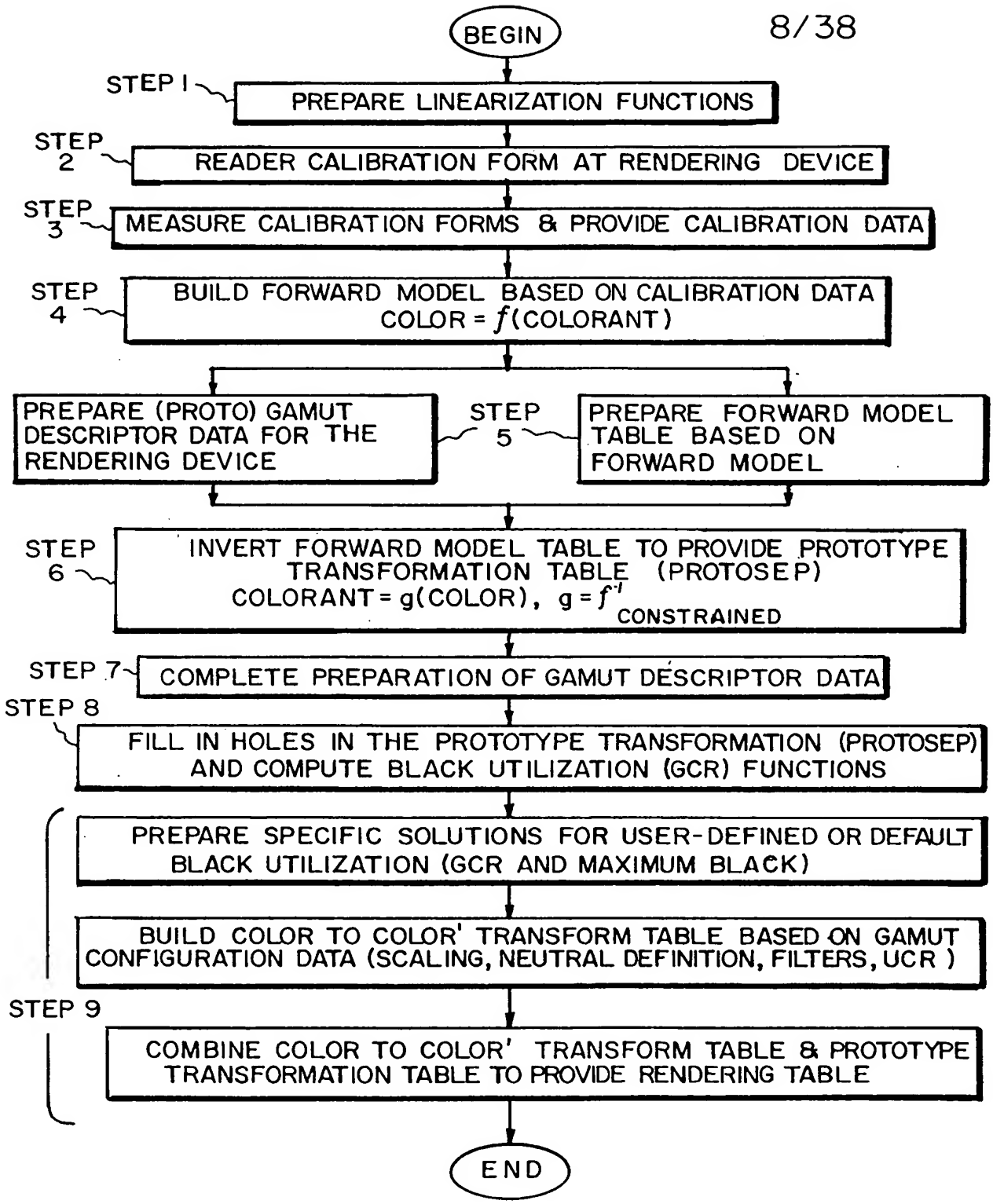

BEGIN
STEP 1
PREPARE LINEARIZATION FUNCTIONS
STEP 2
READER CALIBRATION FORM AT RENDERING DEVICE
STEP 3
MEASURE CALIBRATION FORMS & PROVIDE CALIBRATION DATA
STEP 4
BUILD FORWARD MODEL BASED ON CALIBRATION DATA
COLOR = f(COLORANT)
PREPARE (PROTO) GAMUT DESCRIPTOR DATA FOR THE RENDERING DEVICE
STEP 5
PREPARE FORWARD MODEL TABLE BASED ON FORWARD MODEL
STEP 6
INVERT FORWARD MODEL TABLE TO PROVIDE PROTOTYPE TRANSFORMATION TABLE (PROTOSEP)
COLORANT = g(COLOR), g = f^-1 CONSTRAINED
STEP 7
COMPLETE PREPARATION OF GAMUT DESCRIPTOR DATA
STEP 8
FILL IN HOLES IN THE PROTOTYPE TRANSFORMATION (PROTOSEP) AND COMPUTE BLACK UTILIZATION (GCR) FUNCTIONS
PREPARE SPECIFIC SOLUTIONS FOR USER-DEFINED OR DEFAULT BLACK UTILIZATION (GCR AND MAXIMUM BLACK)
BUILD COLOR TO COLOR' TRANSFORM TABLE BASED ON GAMUT CONFIGURATION DATA (SCALING, NEUTRAL DEFINITION, FILTERS, UCR)
STEP 9
COMBINE COLOR TO COLOR' TRANSFORM TABLE & PROTOTYPE TRANSFORMATION TABLE TO PROVIDE RENDERING TABLE
END

FIG. 5

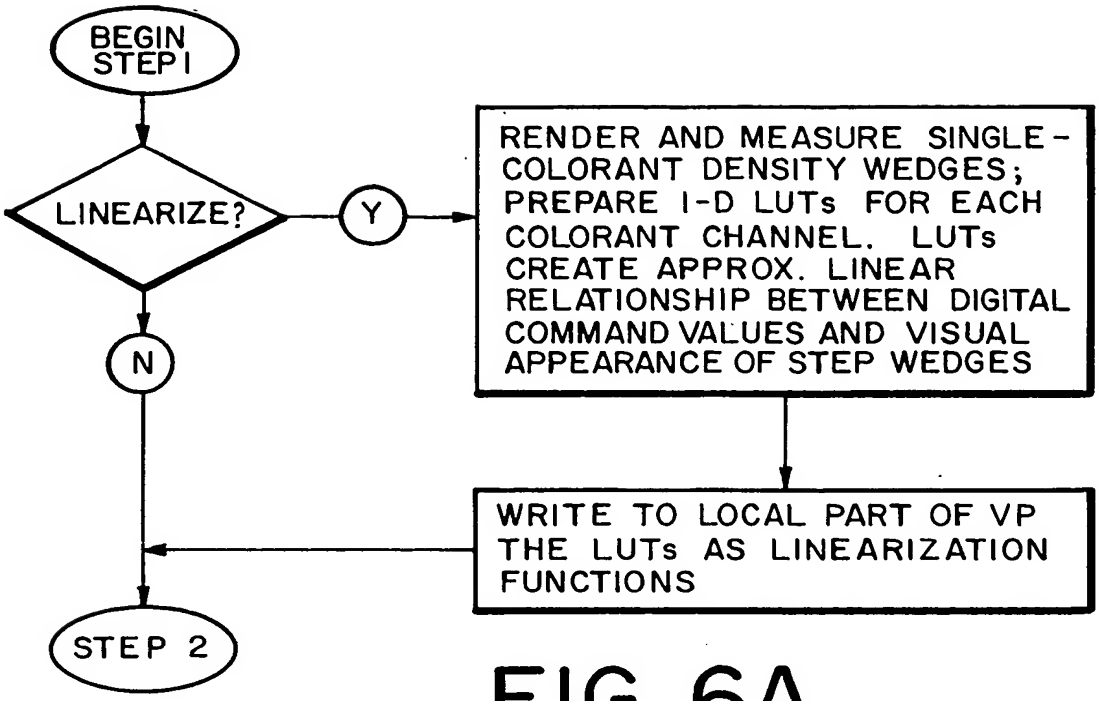

BEGIN STEP1
LINEARIZE?
Y
N
RENDER AND MEASURE SINGLE-COLORANT DENSITY WEDGES; PREPARE 1-D LUTs FOR EACH COLORANT CHANNEL. LUTs CREATE APPROX. LINEAR RELATIONSHIP BETWEEN DIGITAL COMMAND VALUES AND VISUAL APPEARANCE OF STEP WEDGES
WRITE TO LOCAL PART OF VP THE LUTs AS LINEARIZATION FUNCTIONS
STEP 2

FIG. 6A

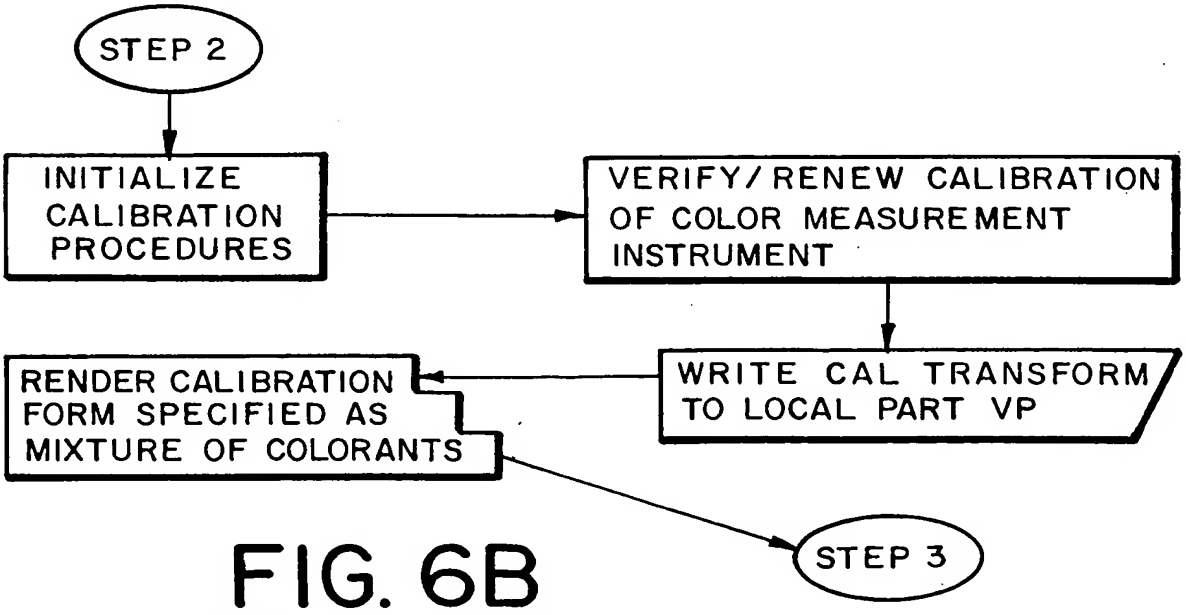

STEP 2
INITIALIZE CALIBRATION PROCEDURES
VERIFY/RENEW CALIBRATION OF COLOR MEASUREMENT INSTRUMENT
WRITE CAL TRANSFORM TO LOCAL PART VP
RENDER CALIBRATION FORM SPECIFIED AS MIXTURE OF COLORANTS
STEP 3

FIG. 6B

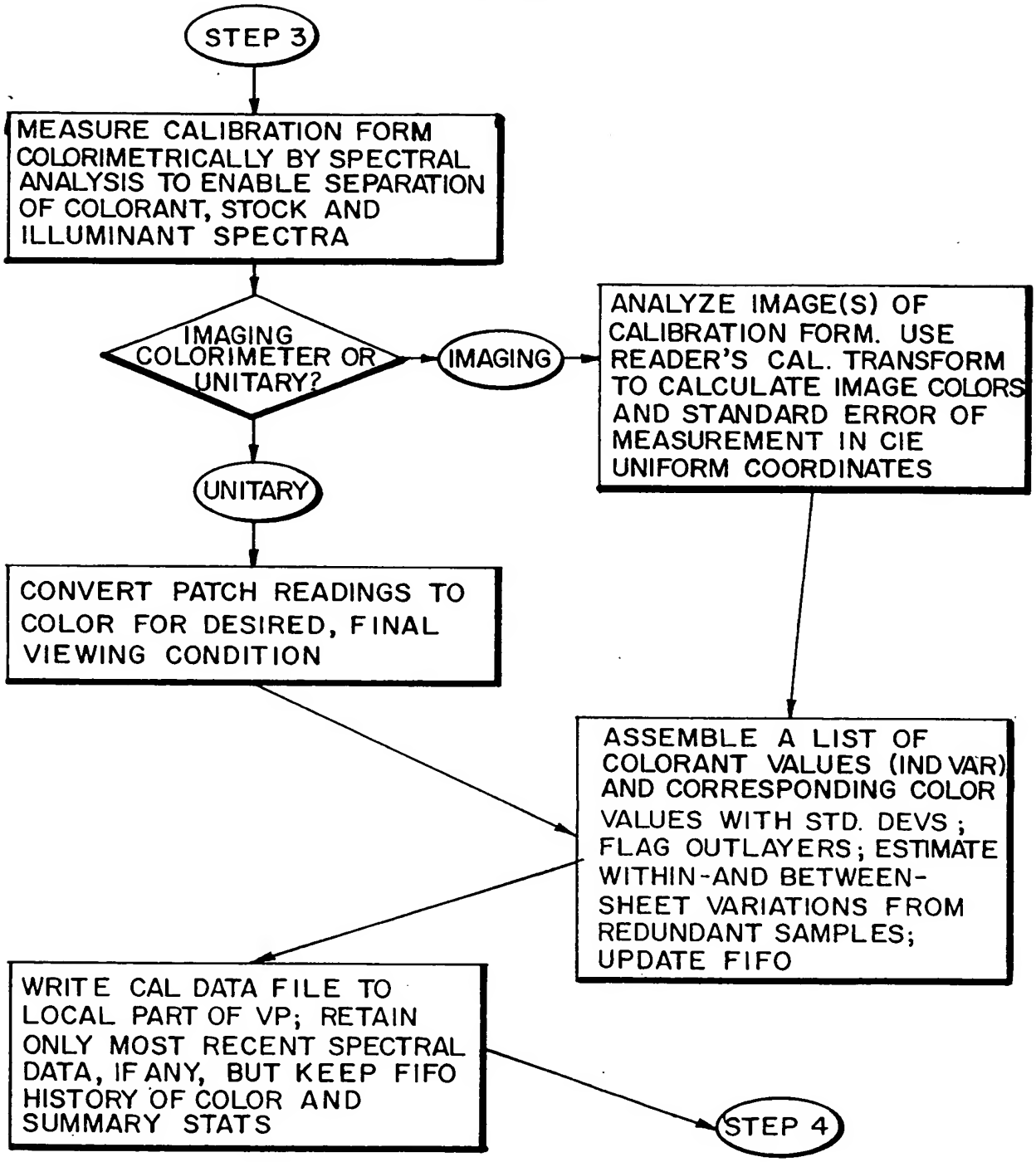

STEP 3
MEASURE CALIBRATION FORM COLORIMETRICALLY BY SPECTRAL ANALYSIS TO ENABLE SEPARATION OF COLORANT, STOCK AND ILLUMINANT SPECTRA
IMAGING COLORIMETER OR UNITARY?
IMAGING
ANALYZE IMAGE(S) OF CALIBRATION FORM. USE READER'S CAL. TRANSFORM TO CALCULATE IMAGE COLORS AND STANDARD ERROR OF MEASUREMENT IN CIE UNIFORM COORDINATES
UNITARY
CONVERT PATCH READINGS TO COLOR FOR DESIRED, FINAL VIEWING CONDITION
ASSEMBLE A LIST OF COLORANT VALUES (IND VAR) AND CORRESPONDING COLOR VALUES WITH STD. DEVS; FLAG OUTLAYERS; ESTIMATE WITHIN-AND BETWEEN-SHEET VARIATIONS FROM REDUNDANT SAMPLES; UPDATE FIFO
WRITE CAL DATA FILE TO LOCAL PART OF VP; RETAIN ONLY MOST RECENT SPECTRAL DATA, IF ANY, BUT KEEP FIFO HISTORY OF COLOR AND SUMMARY STATS
STEP 4

FIG. 7

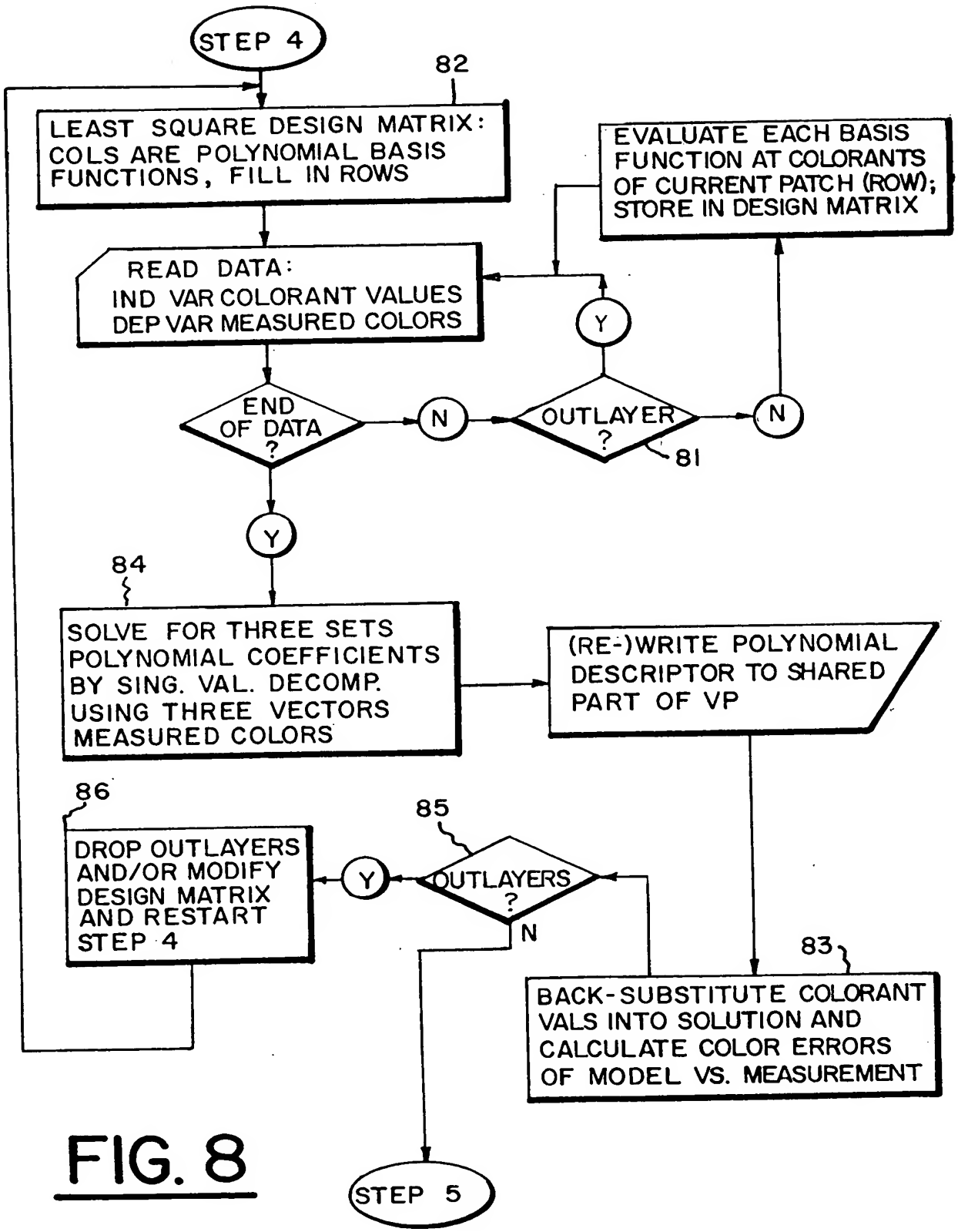

STEP 4
82
LEAST SQUARE DESIGN MATRIX: COLS ARE POLYNOMIAL BASIS FUNCTIONS, FILL IN ROWS
EVALUATE EACH BASIS FUNCTION AT COLORANTS OF CURRENT PATCH (ROW); STORE IN DESIGN MATRIX
READ DATA: IND VAR COLORANT VALUES DEP VAR MEASURED COLORS
Y
END OF DATA ?
N
OUTLAYER ?
81
N
Y
84
SOLVE FOR THREE SETS POLYNOMIAL COEFFICIENTS BY SING. VAL. DECOMP. USING THREE VECTORS MEASURED COLORS
(RE-)WRITE POLYNOMIAL DESCRIPTOR TO SHARED PART OF VP
86
85
DROP OUTLAYERS AND/OR MODIFY DESIGN MATRIX AND RESTART STEP 4
Y
OUTLAYERS ?
N
83
BACK-SUBSTITUTE COLORANT VALS INTO SOLUTION AND CALCULATE COLOR ERRORS OF MODEL VS. MEASUREMENT
STEP 5

FIG. 8

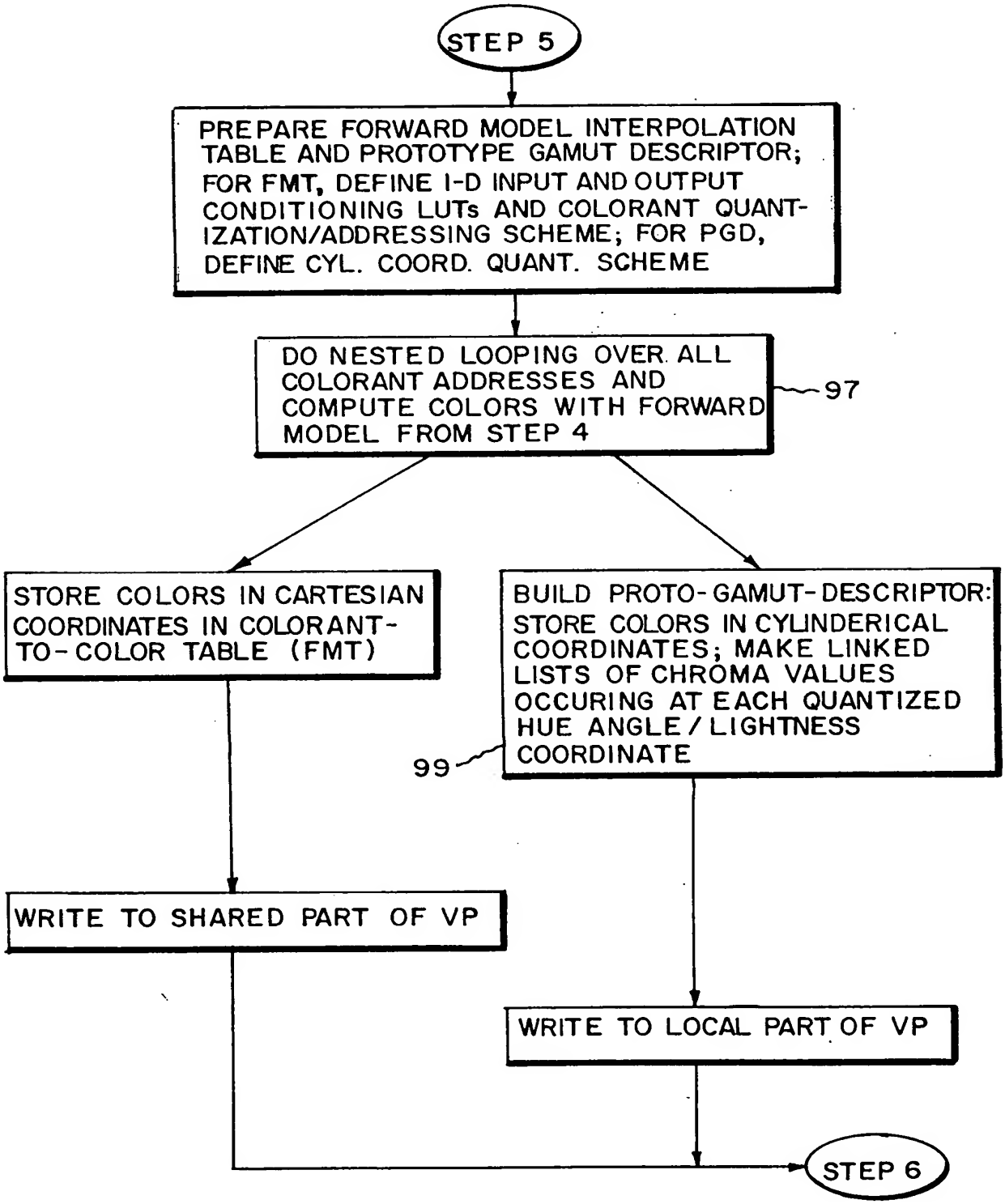

STEP 5
PREPARE FORWARD MODEL INTERPOLATION TABLE AND PROTOTYPE GAMUT DESCRIPTOR; FOR FMT, DEFINE 1-D INPUT AND OUTPUT CONDITIONING LUTs AND COLORANT QUANTIZATION/ADDRESSING SCHEME; FOR PGD, DEFINE CYL. COORD. QUANT. SCHEME
DO NESTED LOOPING OVER ALL COLORANT ADDRESSES AND COMPUTE COLORS WITH FORWARD MODEL FROM STEP 4
97
STORE COLORS IN CARTESIAN COORDINATES IN COLORANT-TO-COLOR TABLE (FMT)
BUILD PROTO-GAMUT-DESCRIPTOR: STORE COLORS IN CYLINDERICAL COORDINATES; MAKE LINKED LISTS OF CHROMA VALUES OCCURING AT EACH QUANTIZED HUE ANGLE / LIGHTNESS COORDINATE
99
WRITE TO SHARED PART OF VP
WRITE TO LOCAL PART OF VP
STEP 6

FIG. 9A

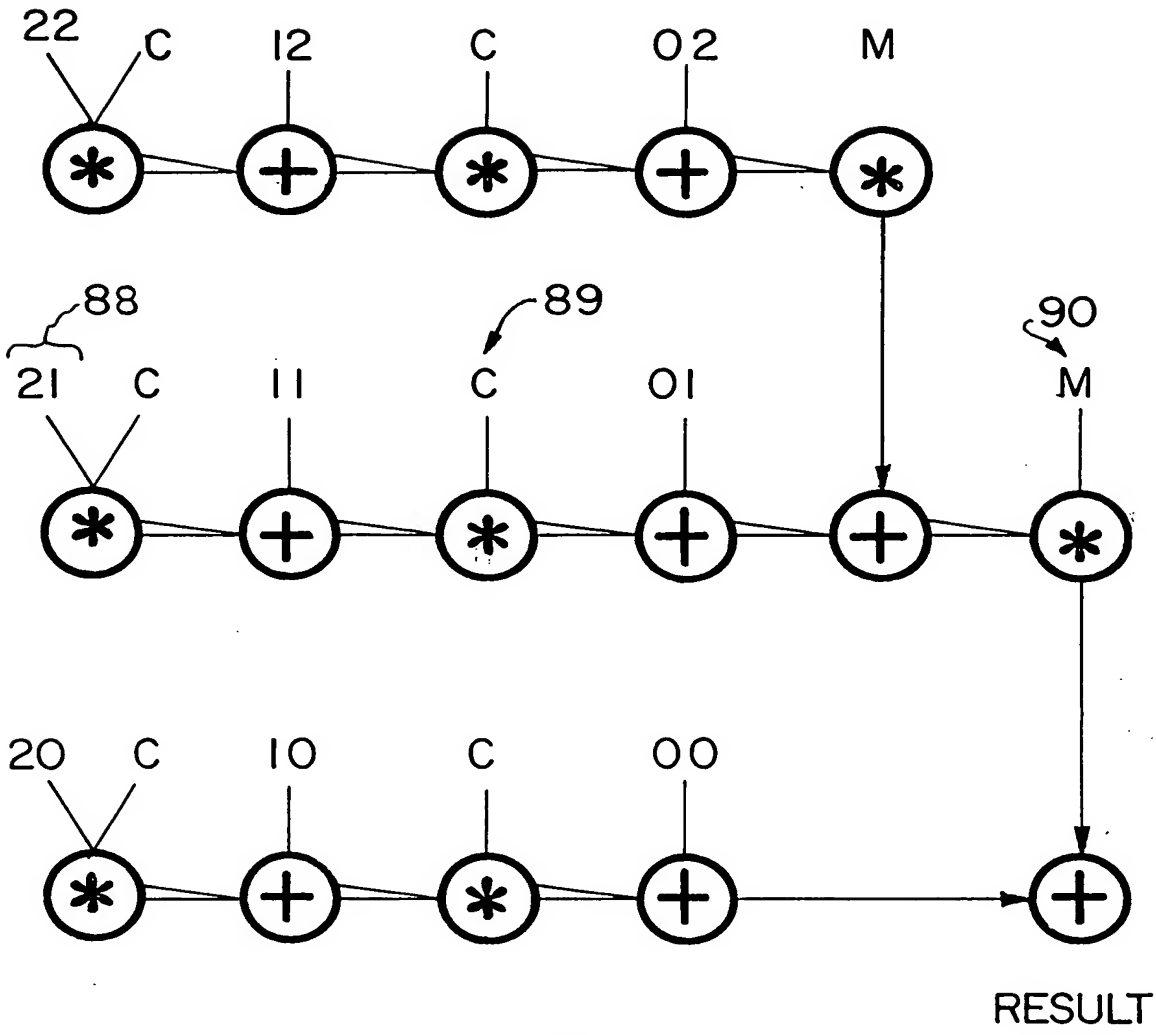

22
C
12
C
02
M
88
89
90
21
C
11
C
01
M
20
C
10
C
00
RESULT
* = MULTIPLY
86
+ = ACCUMULATE
87

FIG. 9B

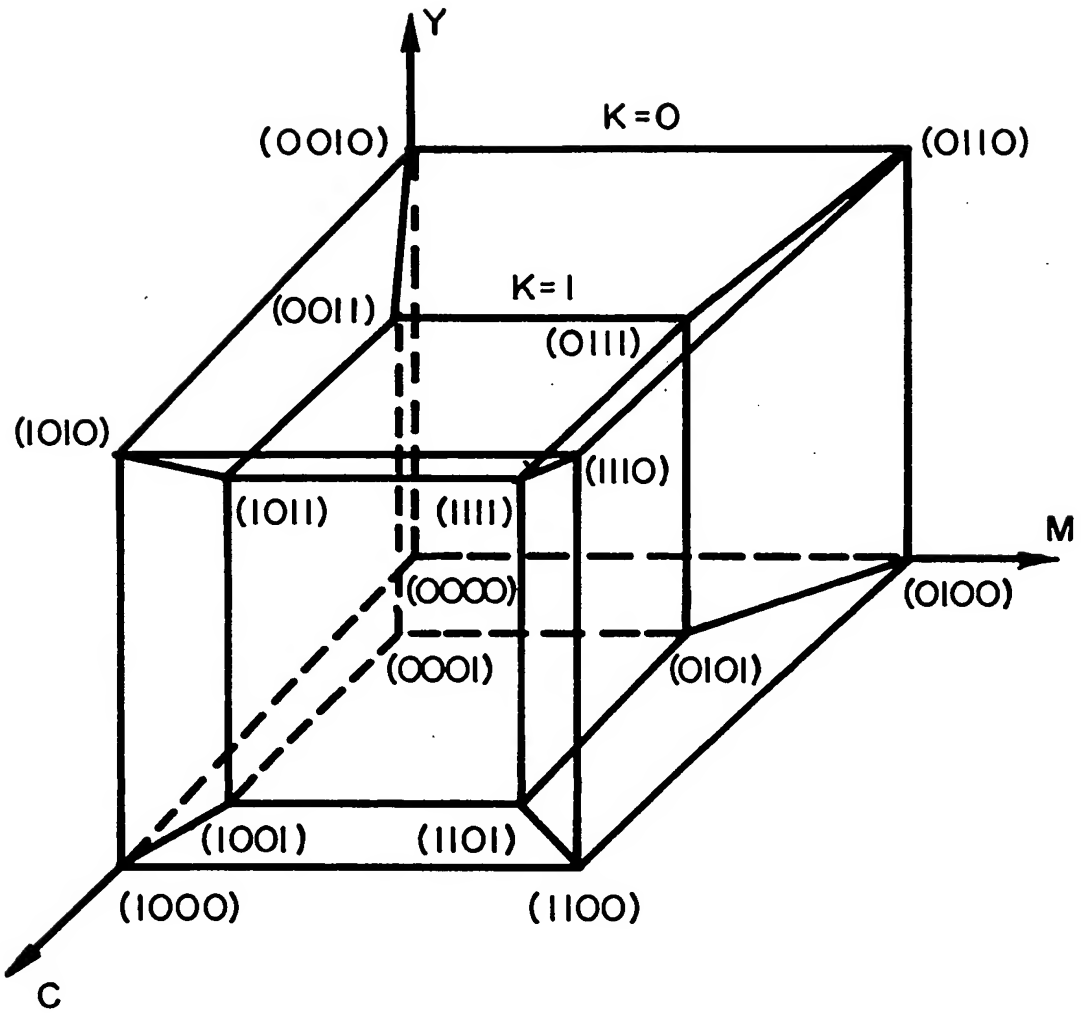

Y
K=0
(0010)
(0110)
K=1
(0011)
(0111)
(1010)
(1110)
(1011)
(1111)
M
(0000)
(0100)
(0001)
(0101)
(1001)
(1101)
(1000)
(1100)
C

FIG. 9C

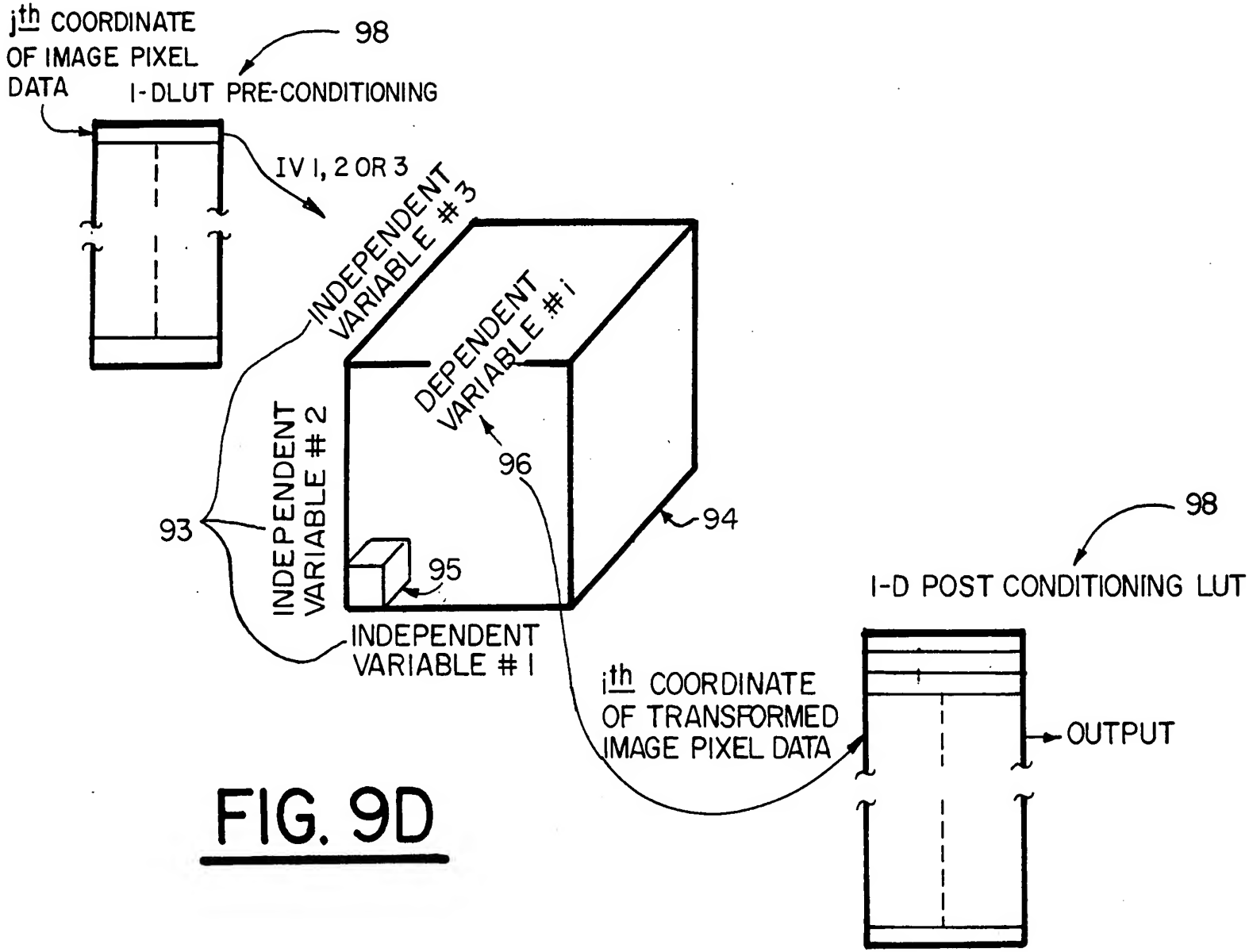

j th COORDINATE OF IMAGE PIXEL DATA
98
I-DLUT PRE-CONDITIONING
IV 1, 2 OR 3
INDEPENDENT VARIABLE #3
DEPENDENT VARIABLE #i
INDEPENDENT VARIABLE #2
93
96
94
95
INDEPENDENT VARIABLE #1
98
I-D POST CONDITIONING LUT
i th COORDINATE OF TRANSFORMED IMAGE PIXEL DATA
OUTPUT

FIG. 9D

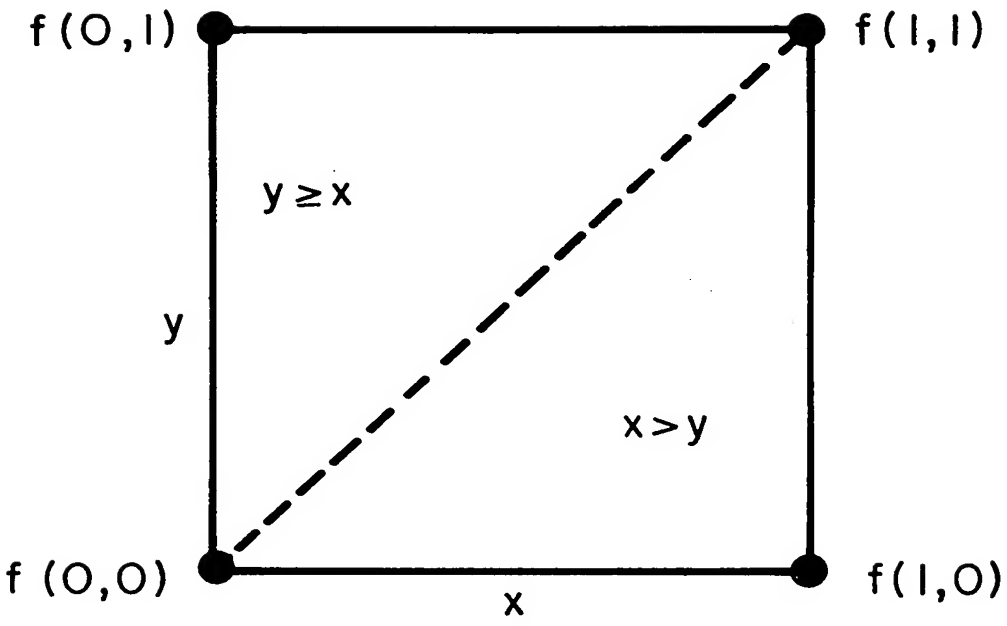


FIG. 9E

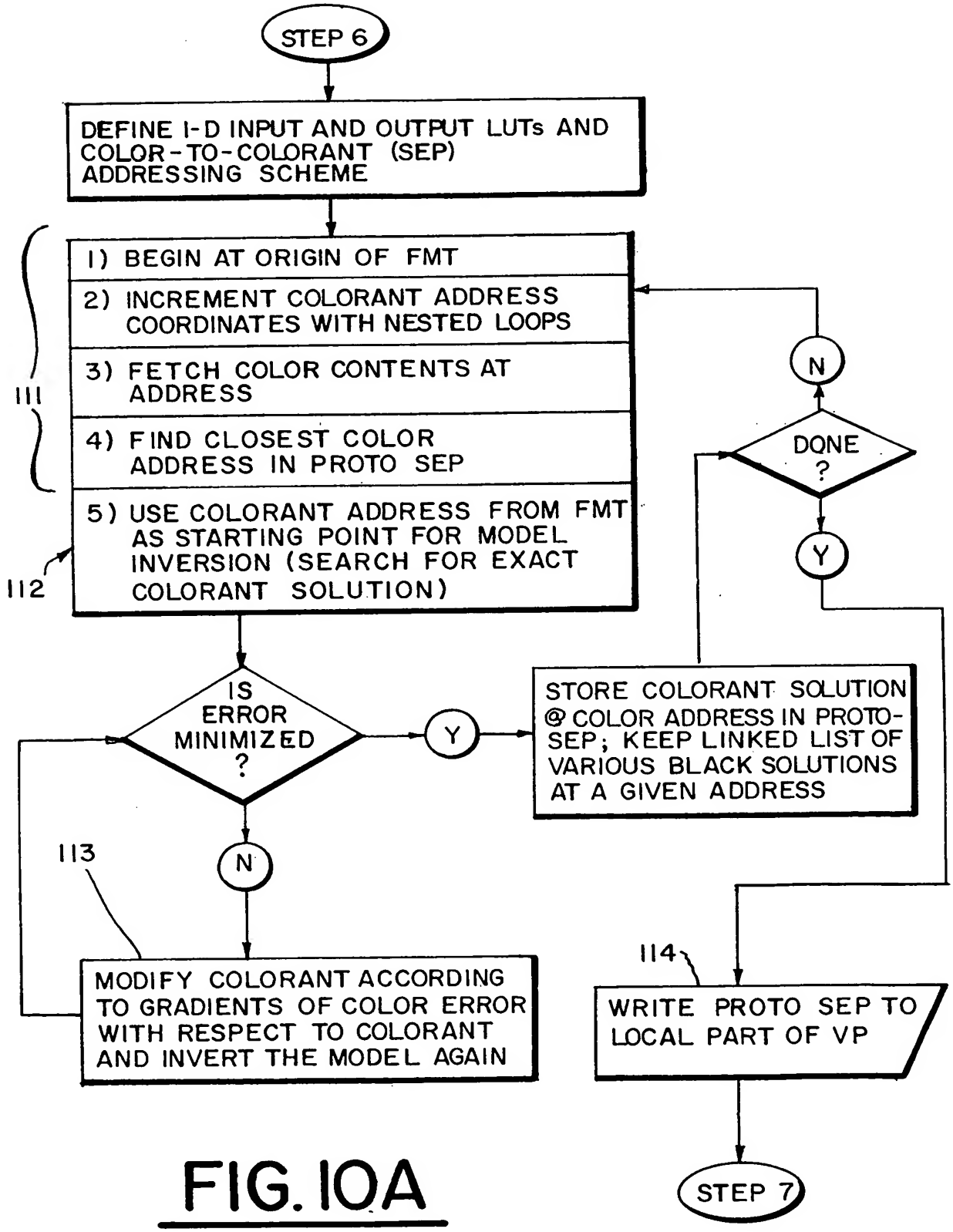

STEP 6
DEFINE 1-D INPUT AND OUTPUT LUTs AND COLOR-TO-COLORANT (SEP) ADDRESSING SCHEME
1) BEGIN AT ORIGIN OF FMT
2) INCREMENT COLORANT ADDRESS COORDINATES WITH NESTED LOOPS
3) FETCH COLOR CONTENTS AT ADDRESS
4) FIND CLOSEST COLOR ADDRESS IN PROTO SEP
111
5) USE COLORANT ADDRESS FROM FMT AS STARTING POINT FOR MODEL INVERSION (SEARCH FOR EXACT COLORANT SOLUTION)
112
N
DONE ?
Y
IS ERROR MINIMIZED ?
Y
STORE COLORANT SOLUTION @ COLOR ADDRESS IN PROTO-SEP; KEEP LINKED LIST OF VARIOUS BLACK SOLUTIONS AT A GIVEN ADDRESS
113
N
MODIFY COLORANT ACCORDING TO GRADIENTS OF COLOR ERROR WITH RESPECT TO COLORANT AND INVERT THE MODEL AGAIN
114
WRITE PROTO SEP TO LOCAL PART OF VP
STEP 7

FIG. 10A

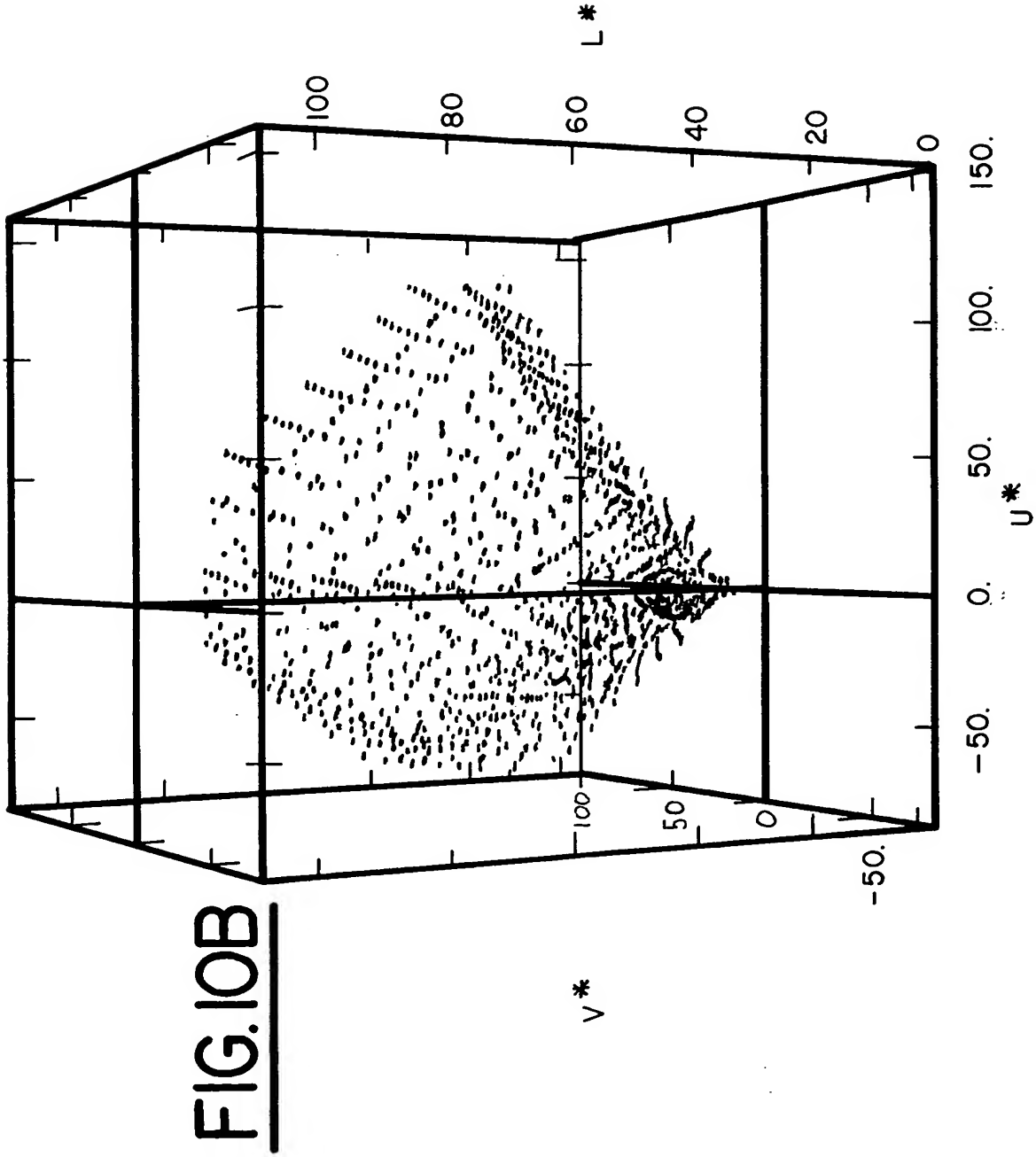


FIG.10B

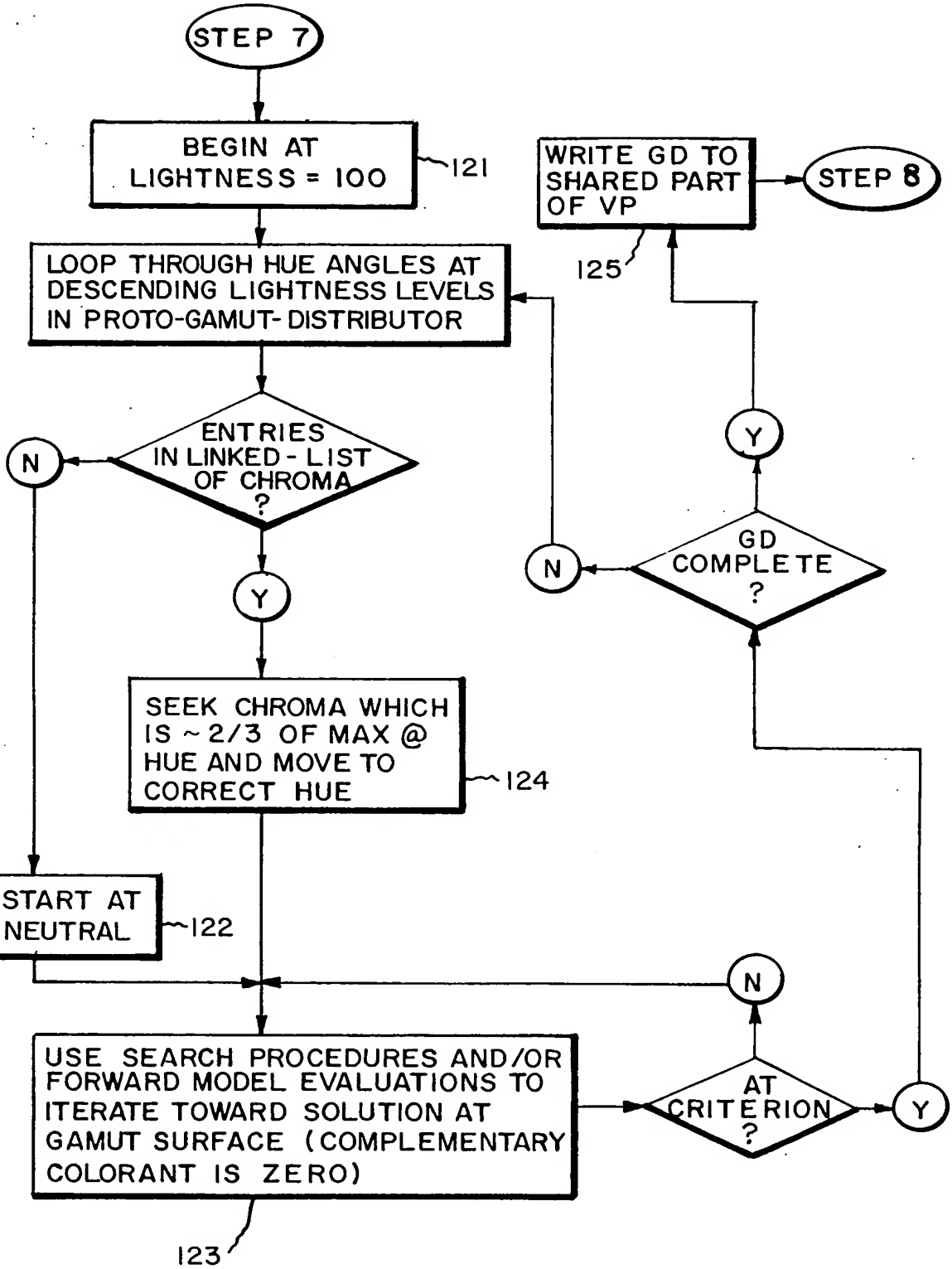

STEP 7
BEGIN AT LIGHTNESS = 100
121
LOOP THROUGH HUE ANGLES AT DESCENDING LIGHTNESS LEVELS IN PROTO-GAMUT-DISTRIBUTOR
ENTRIES IN LINKED-LIST OF CHROMA ?
N
Y
SEEK CHROMA WHICH IS ~2/3 OF MAX @ HUE AND MOVE TO CORRECT HUE
124
START AT NEUTRAL
122
USE SEARCH PROCEDURES AND/OR FORWARD MODEL EVALUATIONS TO ITERATE TOWARD SOLUTION AT GAMUT SURFACE (COMPLEMENTARY COLORANT IS ZERO)
123
AT CRITERION ?
N
Y
GD COMPLETE ?
N
Y
WRITE GD TO SHARED PART OF VP
125
STEP 8

FIG. 11

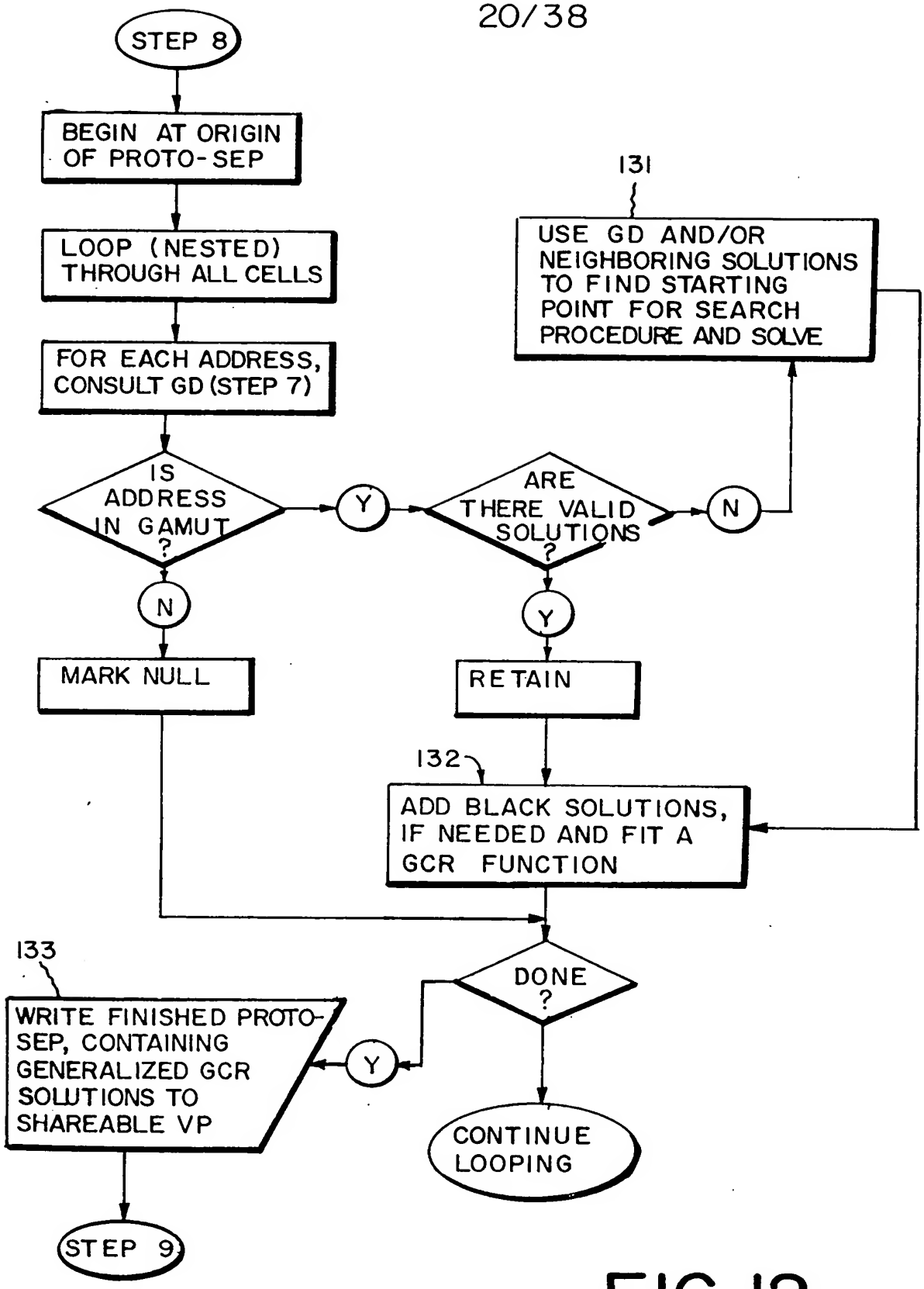

STEP 8
BEGIN AT ORIGIN OF PROTO-SEP
LOOP (NESTED) THROUGH ALL CELLS
FOR EACH ADDRESS, CONSULT GD (STEP 7)
IS ADDRESS IN GAMUT ?
Y
N
MARK NULL
ARE THERE VALID SOLUTIONS ?
N
Y
RETAIN
131
USE GD AND/OR NEIGHBORING SOLUTIONS TO FIND STARTING POINT FOR SEARCH PROCEDURE AND SOLVE
132
ADD BLACK SOLUTIONS, IF NEEDED AND FIT A GCR FUNCTION
DONE ?
Y
133
WRITE FINISHED PROTO-SEP, CONTAINING GENERALIZED GCR SOLUTIONS TO SHAREABLE VP
CONTINUE LOOPING
STEP 9

FIG. 12

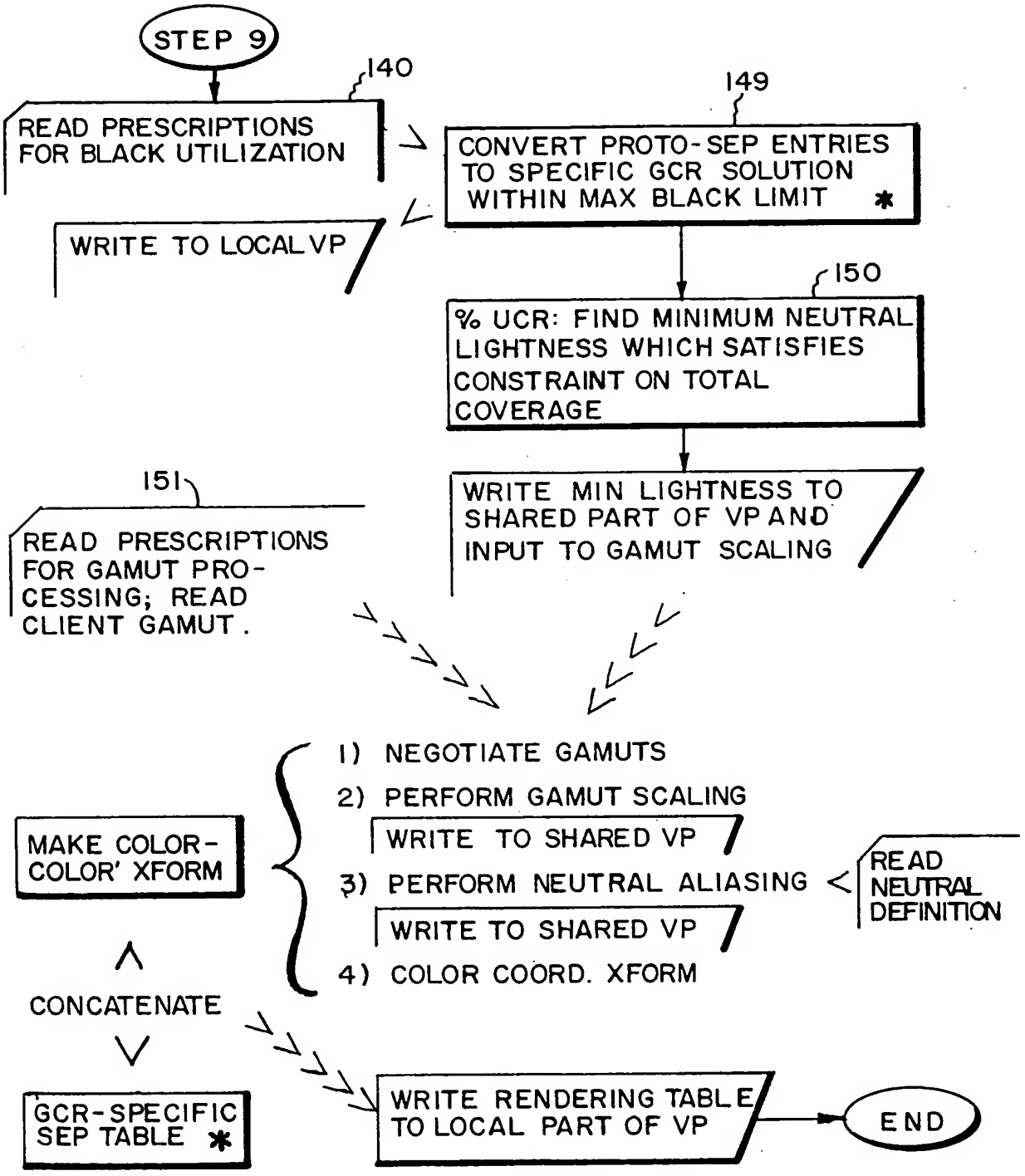
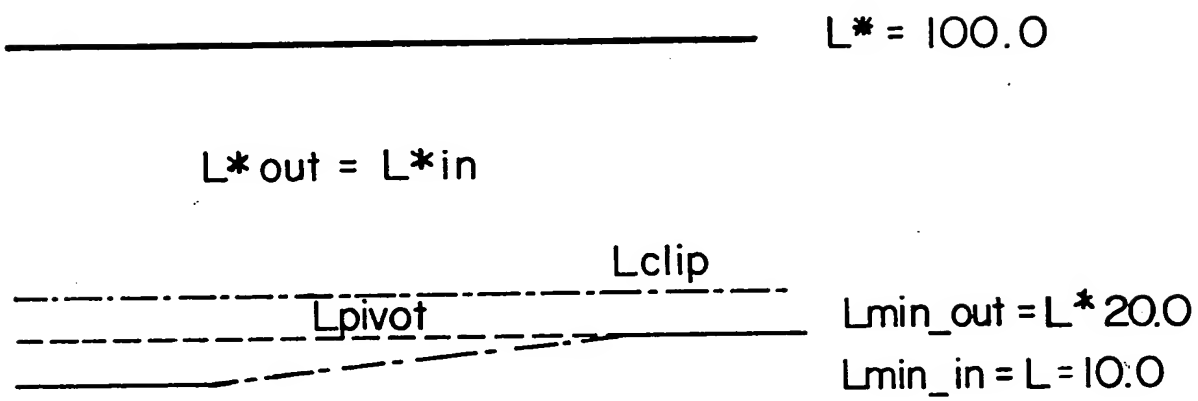

STEP 9
140
READ PRESCRIPTIONS FOR BLACK UTILIZATION
149
CONVERT PROTO-SEP ENTRIES TO SPECIFIC GCR SOLUTION WITHIN MAX BLACK LIMIT *
WRITE TO LOCAL VP
150
% UCR: FIND MINIMUM NEUTRAL LIGHTNESS WHICH SATISFIES CONSTRAINT ON TOTAL COVERAGE
WRITE MIN LIGHTNESS TO SHARED PART OF VP AND INPUT TO GAMUT SCALING
151
READ PRESCRIPTIONS FOR GAMUT PROCESSING; READ CLIENT GAMUT.
1) NEGOTIATE GAMUTS
2) PERFORM GAMUT SCALING
WRITE TO SHARED VP
3) PERFORM NEUTRAL ALIASING
READ NEUTRAL DEFINITION
WRITE TO SHARED VP
4) COLOR COORD. XFORM
MAKE COLOR-COLOR' XFORM
CONCATENATE
GCR-SPECIFIC SEP TABLE *
WRITE RENDERING TABLE TO LOCAL PART OF VP
END

FIG. 13

CASE 1: THE MINIMUM INPUT L* IS LESS THAN MINIMUM OUTPUT L*



CASE 2: THE MINIMUM INPUT L* IS GREATER THAN MINIMUM OUTPUT L*

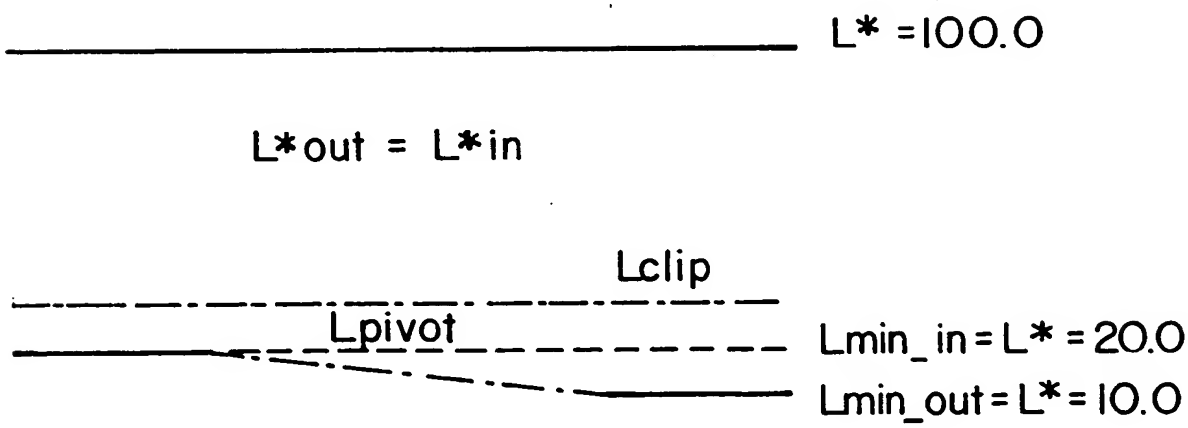


FIG. 14

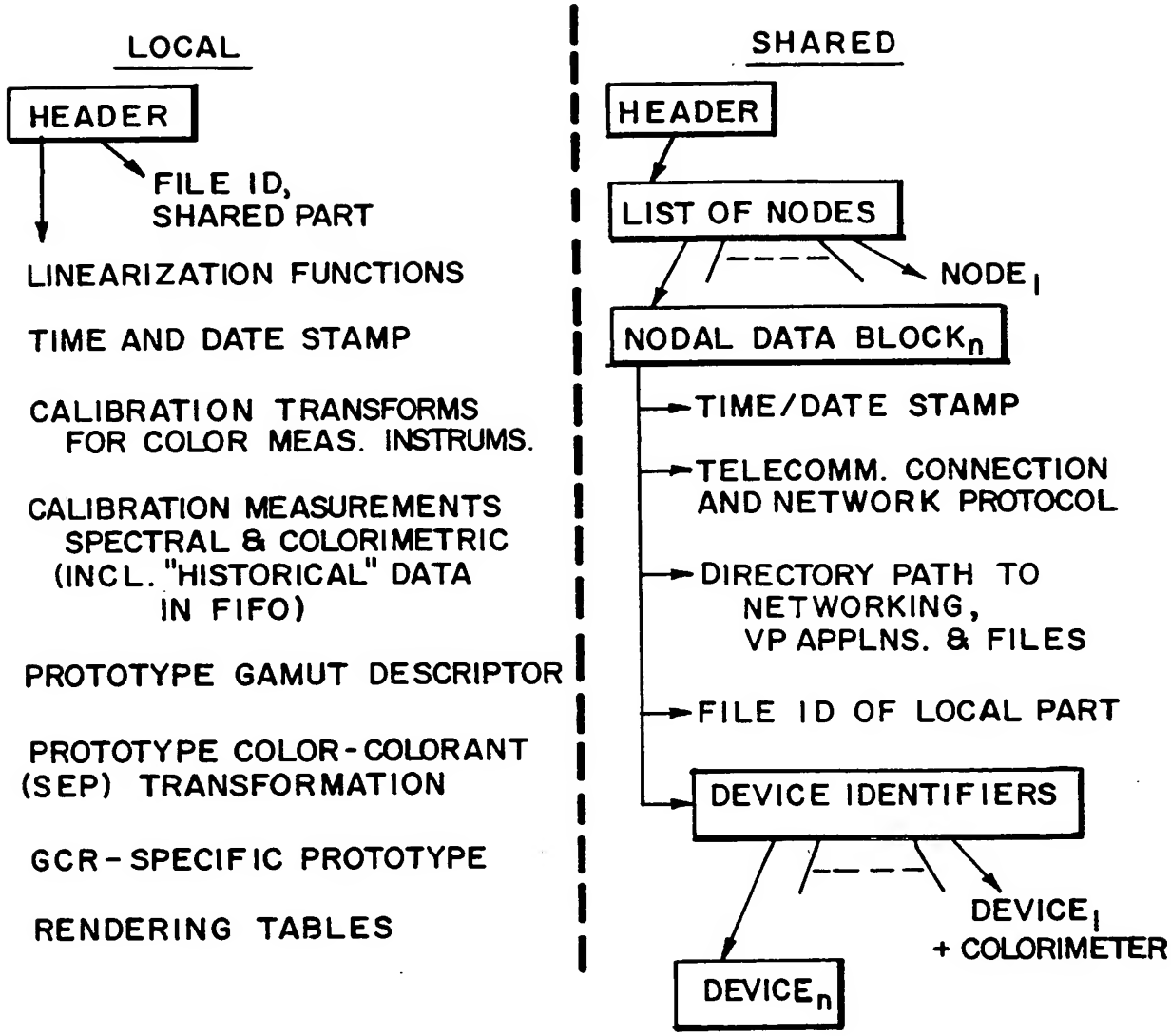

LOCAL
HEADER
FILE ID,
SHARED PART
LINEARIZATION FUNCTIONS
TIME AND DATE STAMP
CALIBRATION TRANSFORMS FOR COLOR MEAS. INSTRUMS.
CALIBRATION MEASUREMENTS SPECTRAL & COLORIMETRIC (INCL. "HISTORICAL" DATA IN FIFO)
PROTOTYPE GAMUT DESCRIPTOR
PROTOTYPE COLOR-COLORANT (SEP) TRANSFORMATION
GCR-SPECIFIC PROTOTYPE
RENDERING TABLES
SHARED
HEADER
LIST OF NODES
NODE$_1$
NODAL DATA BLOCK$_n$
TIME/DATE STAMP
TELECOMM. CONNECTION AND NETWORK PROTOCOL
DIRECTORY PATH TO NETWORKING, VP APPLNS. & FILES
FILE ID OF LOCAL PART
DEVICE IDENTIFIERS
DEVICE$_1$ + COLORIMETER
DEVICE$_n$

FIG. 15A

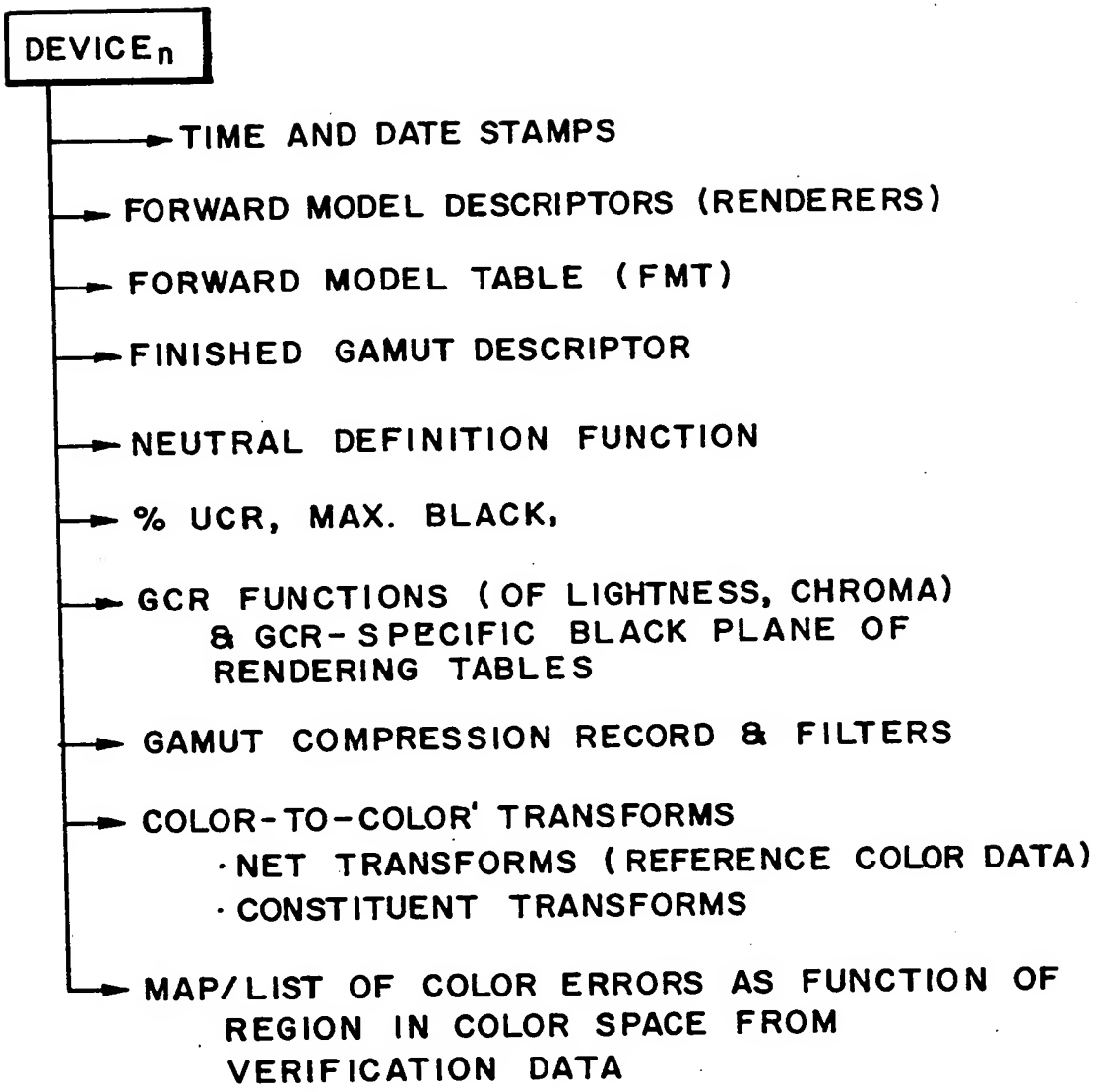

DEVICEn
TIME AND DATE STAMPS
FORWARD MODEL DESCRIPTORS (RENDERERS)
FORWARD MODEL TABLE (FMT)
FINISHED GAMUT DESCRIPTOR
NEUTRAL DEFINITION FUNCTION
% UCR, MAX. BLACK,
GCR FUNCTIONS (OF LIGHTNESS, CHROMA) & GCR-SPECIFIC BLACK PLANE OF RENDERING TABLES
GAMUT COMPRESSION RECORD & FILTERS
COLOR-TO-COLOR' TRANSFORMS
· NET TRANSFORMS (REFERENCE COLOR DATA)
· CONSTITUENT TRANSFORMS
MAP/LIST OF COLOR ERRORS AS FUNCTION OF REGION IN COLOR SPACE FROM VERIFICATION DATA

FIG. 15B

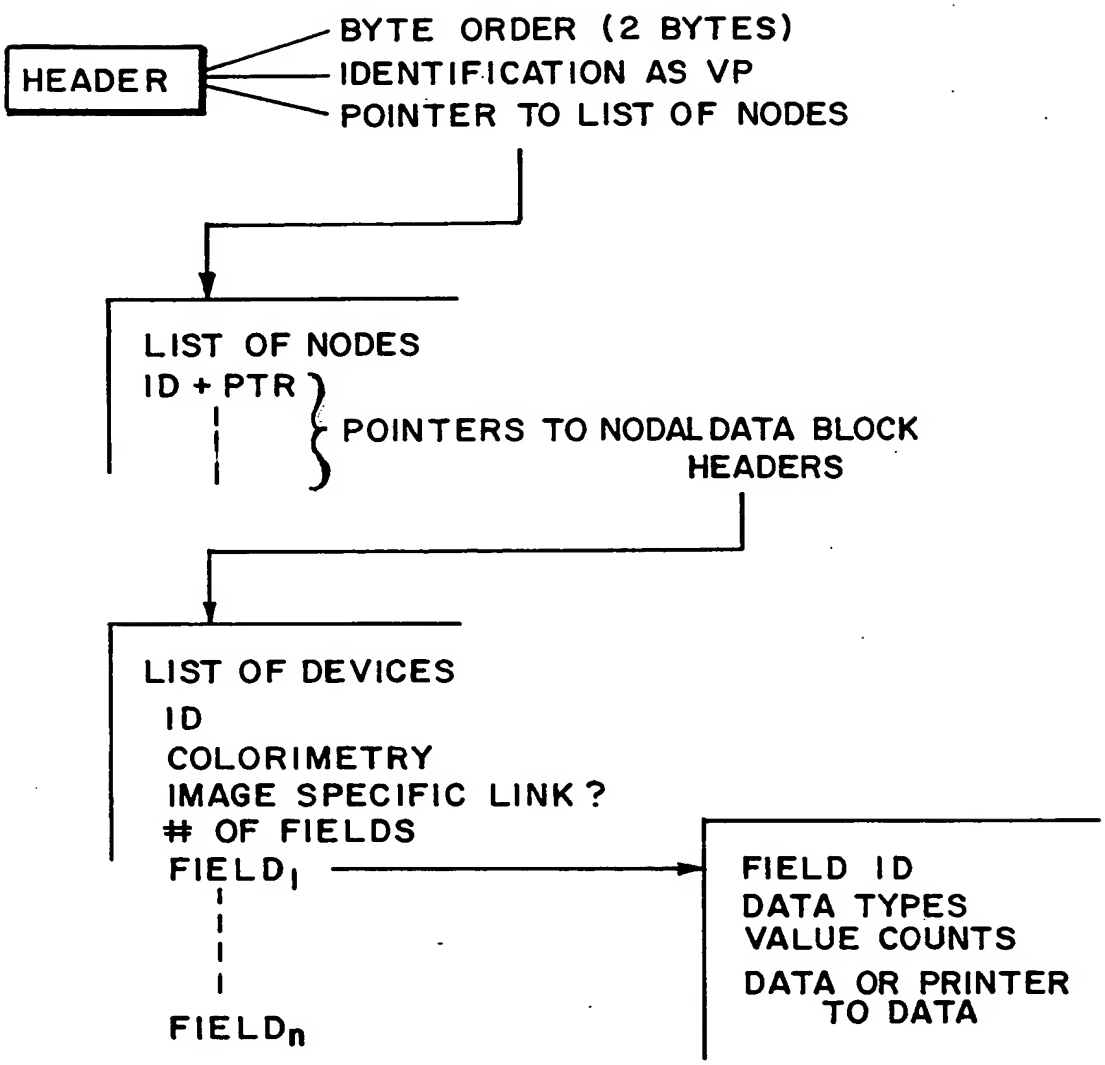

HEADER
BYTE ORDER (2 BYTES)
IDENTIFICATION AS VP
POINTER TO LIST OF NODES
LIST OF NODES
ID + PTR
POINTERS TO NODAL DATA BLOCK HEADERS
LIST OF DEVICES
ID
COLORIMETRY
IMAGE SPECIFIC LINK?
OF FIELDS
FIELD1
FIELDn
FIELD ID
DATA TYPES
VALUE COUNTS
DATA OR PRINTER TO DATA

FIG. 15C

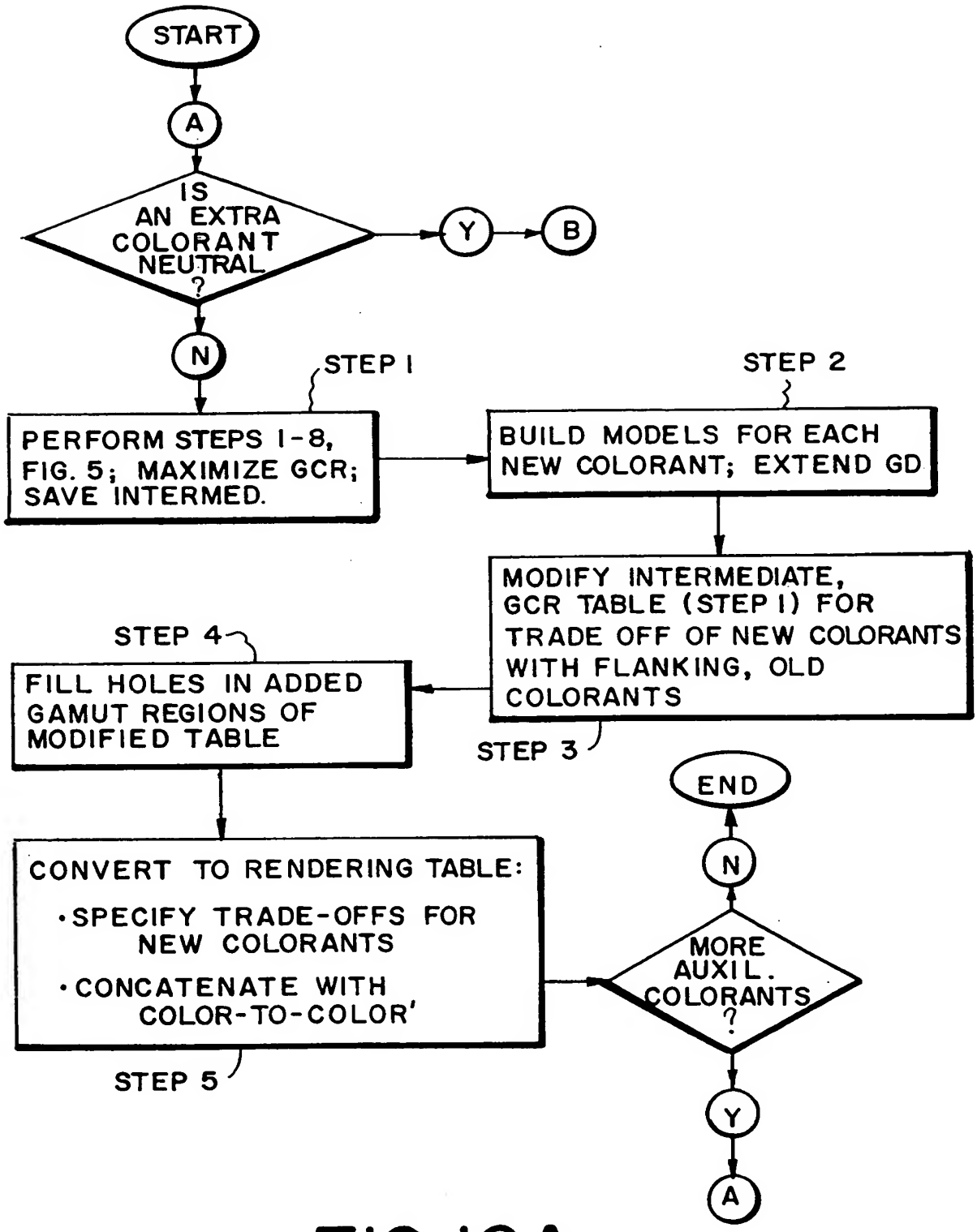

START
A
IS AN EXTRA COLORANT NEUTRAL ?
Y
B
N
STEP 1
PERFORM STEPS 1-8, FIG. 5; MAXIMIZE GCR; SAVE INTERMED.
STEP 2
BUILD MODELS FOR EACH NEW COLORANT; EXTEND GD
MODIFY INTERMEDIATE, GCR TABLE (STEP 1) FOR TRADE OFF OF NEW COLORANTS WITH FLANKING, OLD COLORANTS
STEP 3
STEP 4
FILL HOLES IN ADDED GAMUT REGIONS OF MODIFIED TABLE
CONVERT TO RENDERING TABLE:
• SPECIFY TRADE-OFFS FOR NEW COLORANTS
• CONCATENATE WITH COLOR-TO-COLOR'
STEP 5
MORE AUXIL. COLORANTS ?
N
END
Y
A

FIG. 16A

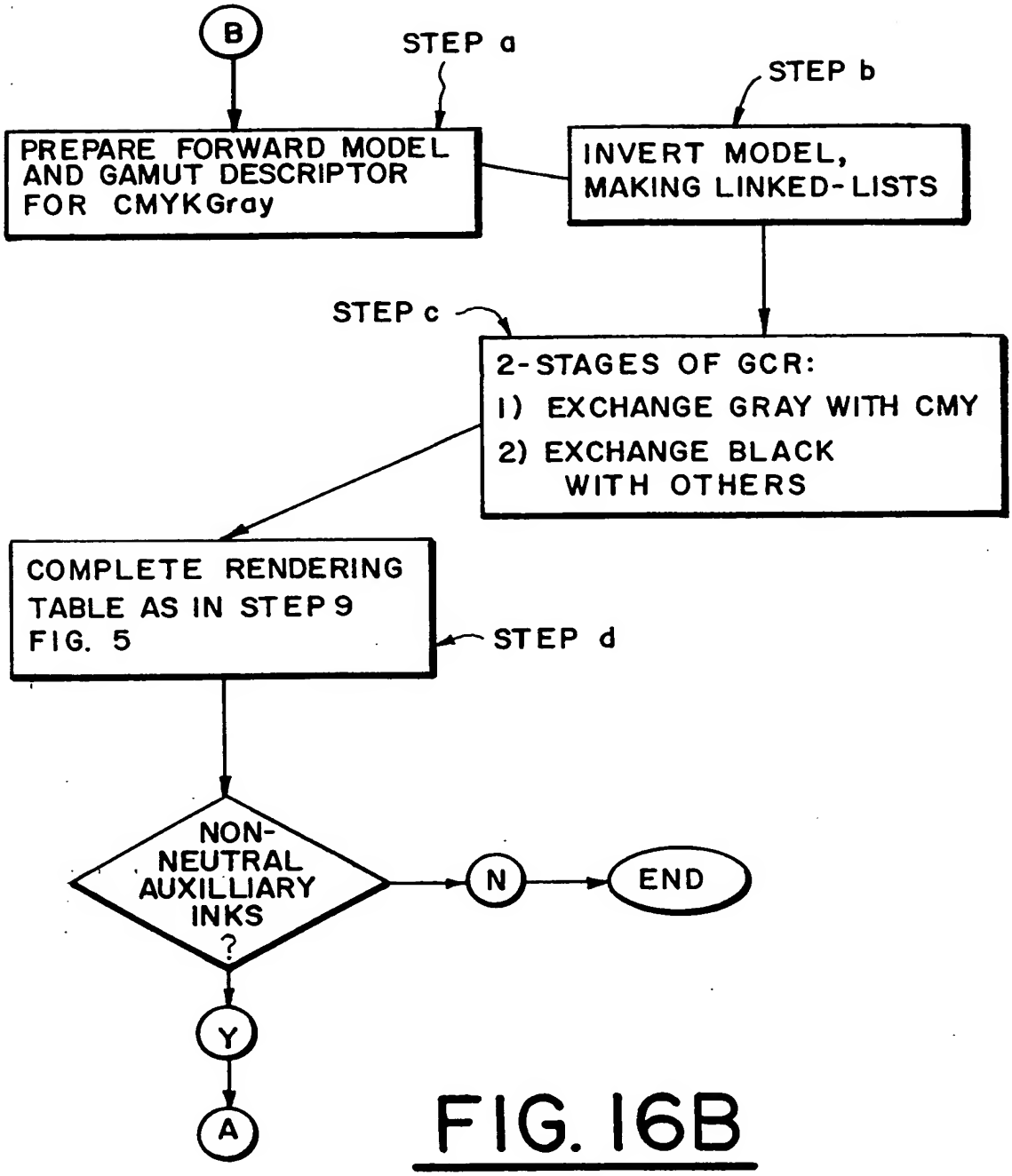

B
STEP a
STEP b
PREPARE FORWARD MODEL AND GAMUT DESCRIPTOR FOR CMYKGray
INVERT MODEL, MAKING LINKED-LISTS
STEP c
2-STAGES OF GCR:
1) EXCHANGE GRAY WITH CMY
2) EXCHANGE BLACK WITH OTHERS
COMPLETE RENDERING TABLE AS IN STEP 9 FIG. 5
STEP d
NON-NEUTRAL AUXILLIARY INKS ?
N
END
Y
A

FIG. 16B

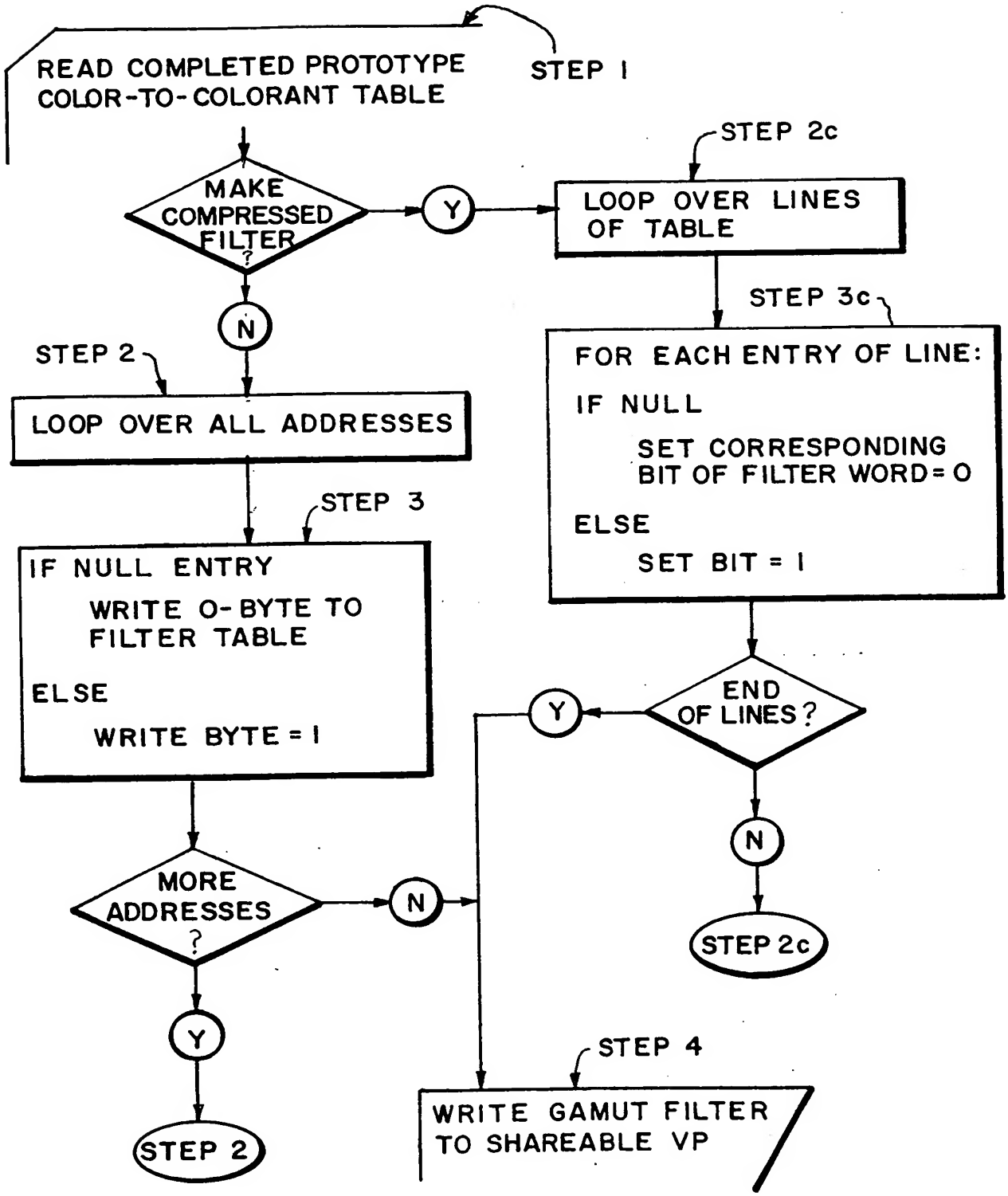

READ COMPLETED PROTOTYPE COLOR-TO-COLORANT TABLE
STEP 1
MAKE COMPRESSED FILTER ?
Y
N
STEP 2c
LOOP OVER LINES OF TABLE
STEP 3c
FOR EACH ENTRY OF LINE:
IF NULL
SET CORRESPONDING BIT OF FILTER WORD = 0
ELSE
SET BIT = 1
STEP 2
LOOP OVER ALL ADDRESSES
STEP 3
IF NULL ENTRY
WRITE 0-BYTE TO FILTER TABLE
ELSE
WRITE BYTE = 1
END OF LINES ?
Y
N
STEP 2c
MORE ADDRESSES ?
N
Y
STEP 2
STEP 4
WRITE GAMUT FILTER TO SHAREABLE VP

FIG. 17

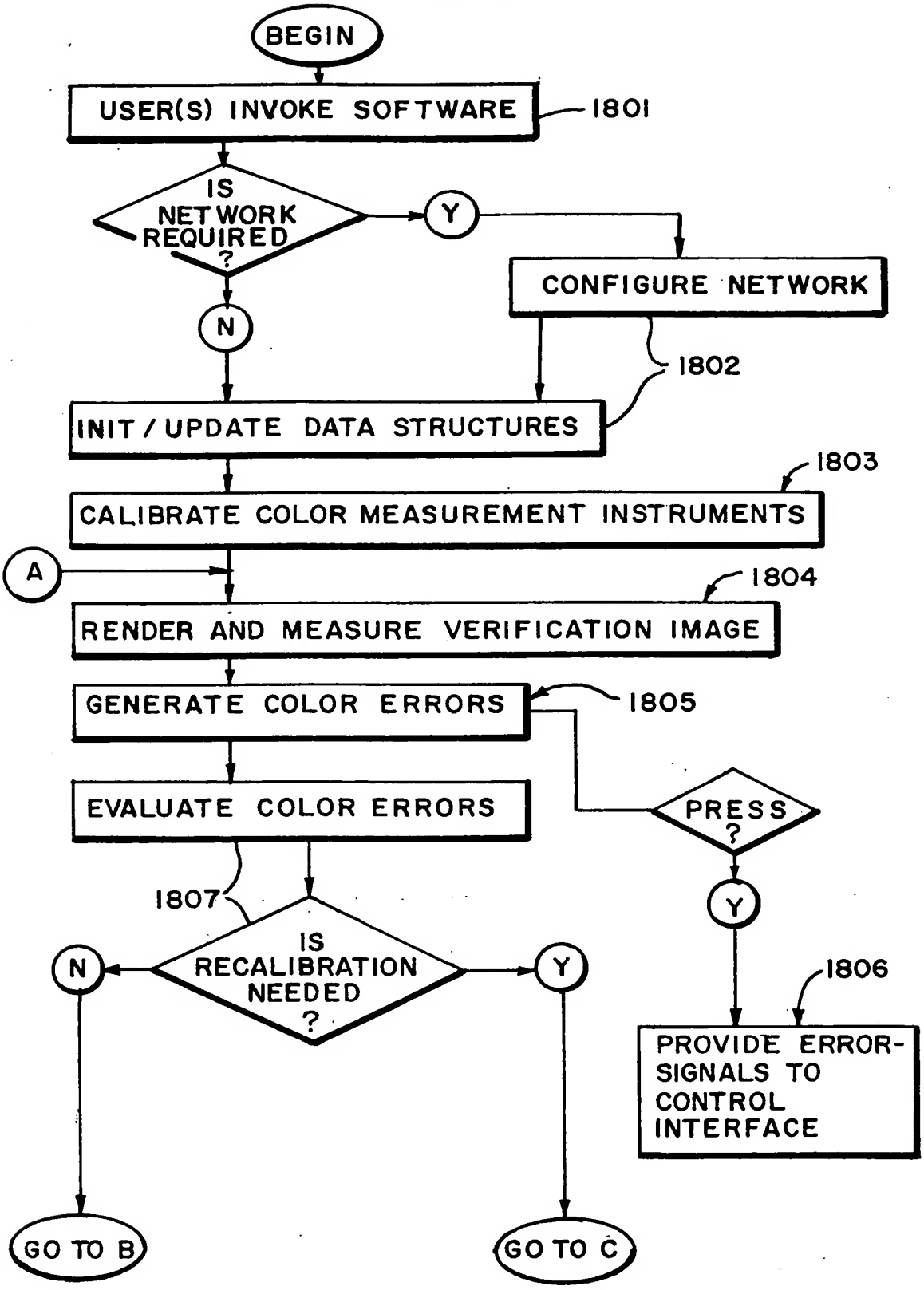

BEGIN
USER(S) INVOKE SOFTWARE
1801
IS NETWORK REQUIRED ?
Y
N
CONFIGURE NETWORK
1802
INIT / UPDATE DATA STRUCTURES
1803
CALIBRATE COLOR MEASUREMENT INSTRUMENTS
A
1804
RENDER AND MEASURE VERIFICATION IMAGE
GENERATE COLOR ERRORS
1805
EVALUATE COLOR ERRORS
PRESS ?
Y
1807
IS RECALIBRATION NEEDED ?
N
Y
1806
PROVIDE ERROR-SIGNALS TO CONTROL INTERFACE
GO TO B
GO TO C

FIG. 18A

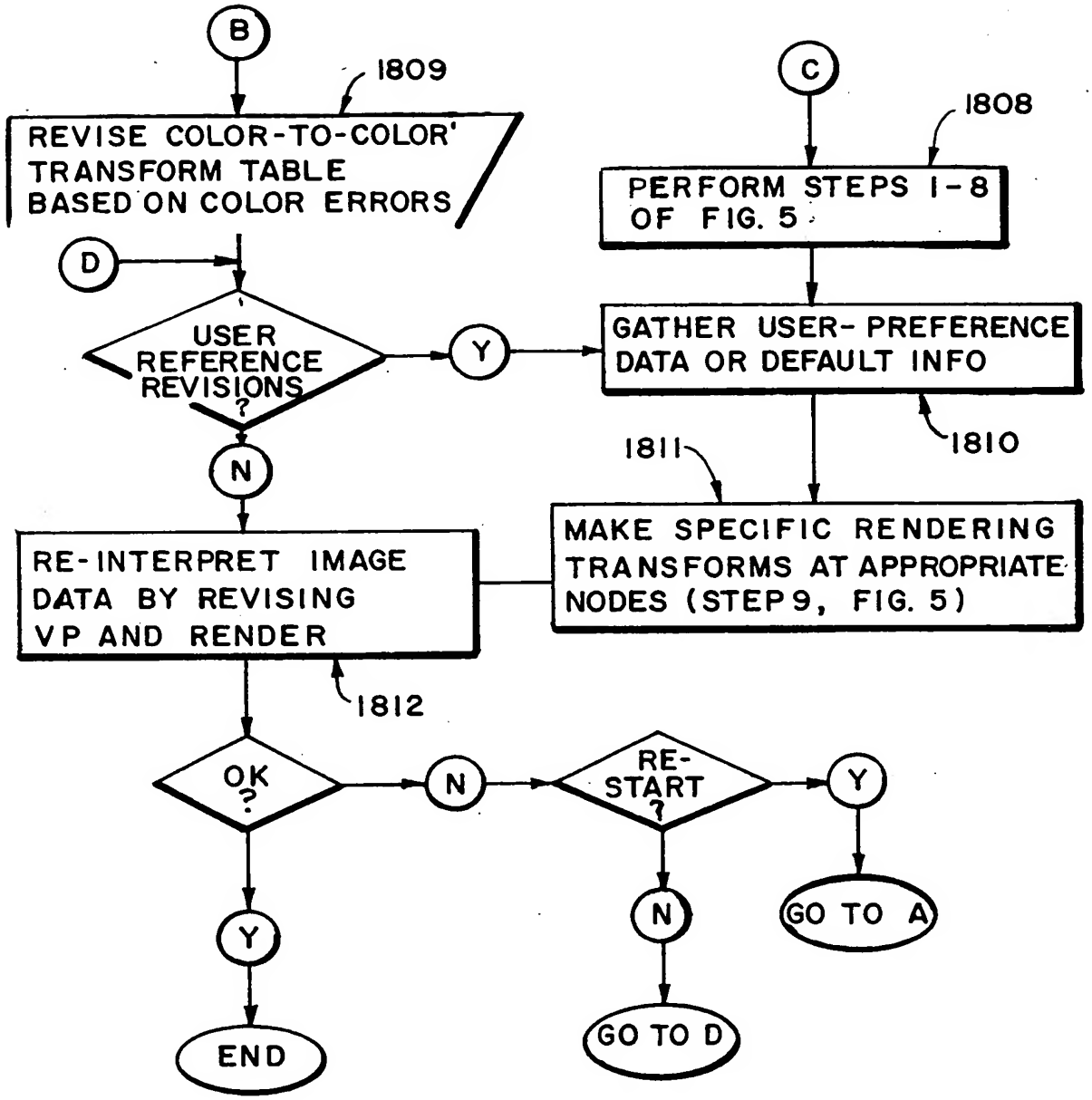

B
1809
REVISE COLOR-TO-COLOR' TRANSFORM TABLE BASED ON COLOR ERRORS
C
1808
PERFORM STEPS 1-8 OF FIG. 5
D
USER REFERENCE REVISIONS ?
Y
GATHER USER-PREFERENCE DATA OR DEFAULT INFO
1810
1811
N
MAKE SPECIFIC RENDERING TRANSFORMS AT APPROPRIATE NODES (STEP 9, FIG. 5)
RE-INTERPRET IMAGE DATA BY REVISING VP AND RENDER
1812
OK ?
N
RE-START ?
Y
Y
N
GO TO A
END
GO TO D

FIG. 18B

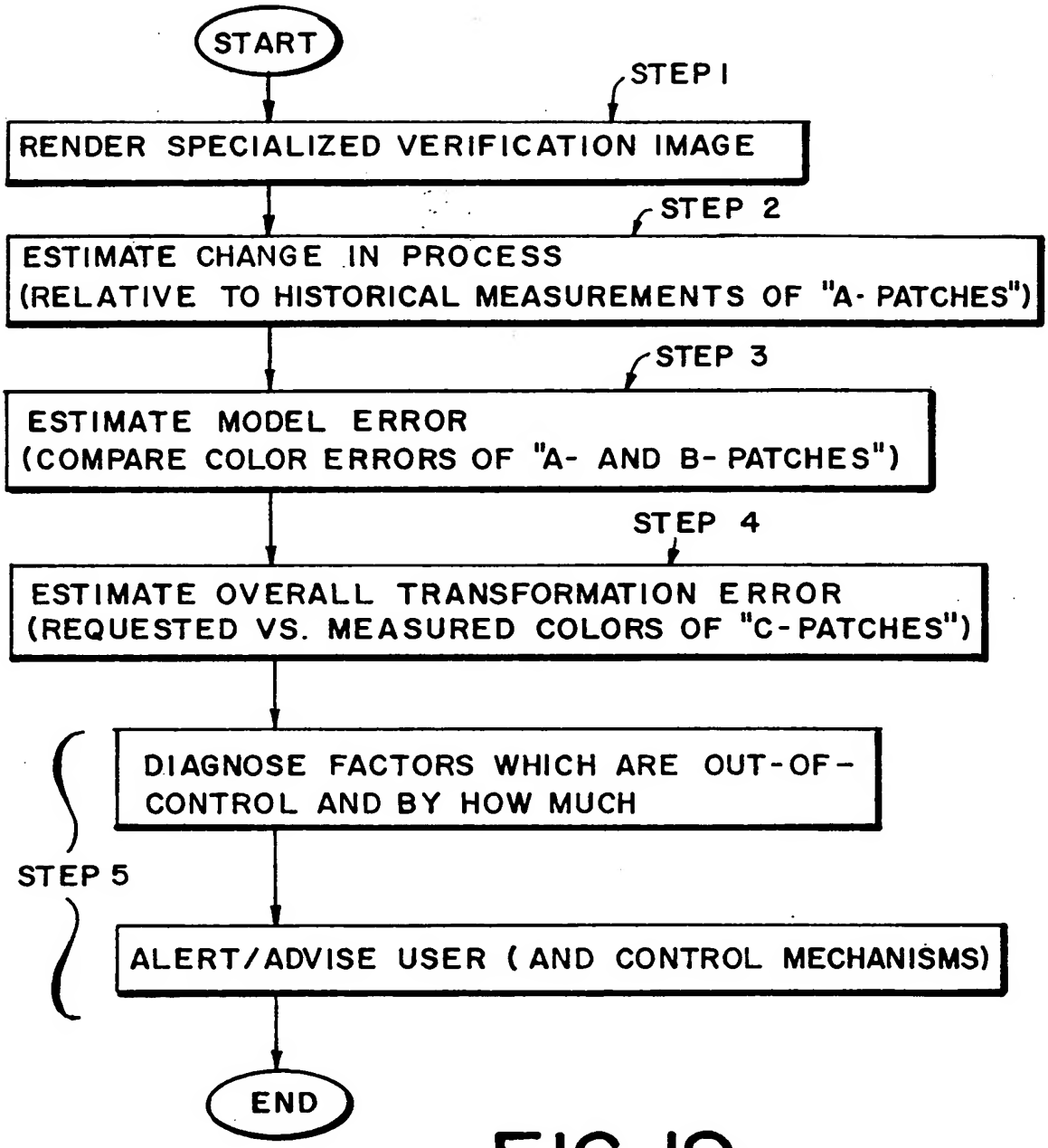

START
STEP 1
RENDER SPECIALIZED VERIFICATION IMAGE
STEP 2
ESTIMATE CHANGE IN PROCESS
(RELATIVE TO HISTORICAL MEASUREMENTS OF "A- PATCHES")
STEP 3
ESTIMATE MODEL ERROR
(COMPARE COLOR ERRORS OF "A- AND B- PATCHES")
STEP 4
ESTIMATE OVERALL TRANSFORMATION ERROR
(REQUESTED VS. MEASURED COLORS OF "C- PATCHES")
DIAGNOSE FACTORS WHICH ARE OUT-OF-CONTROL AND BY HOW MUCH
STEP 5
ALERT/ADVISE USER (AND CONTROL MECHANISMS)
END

FIG. 19

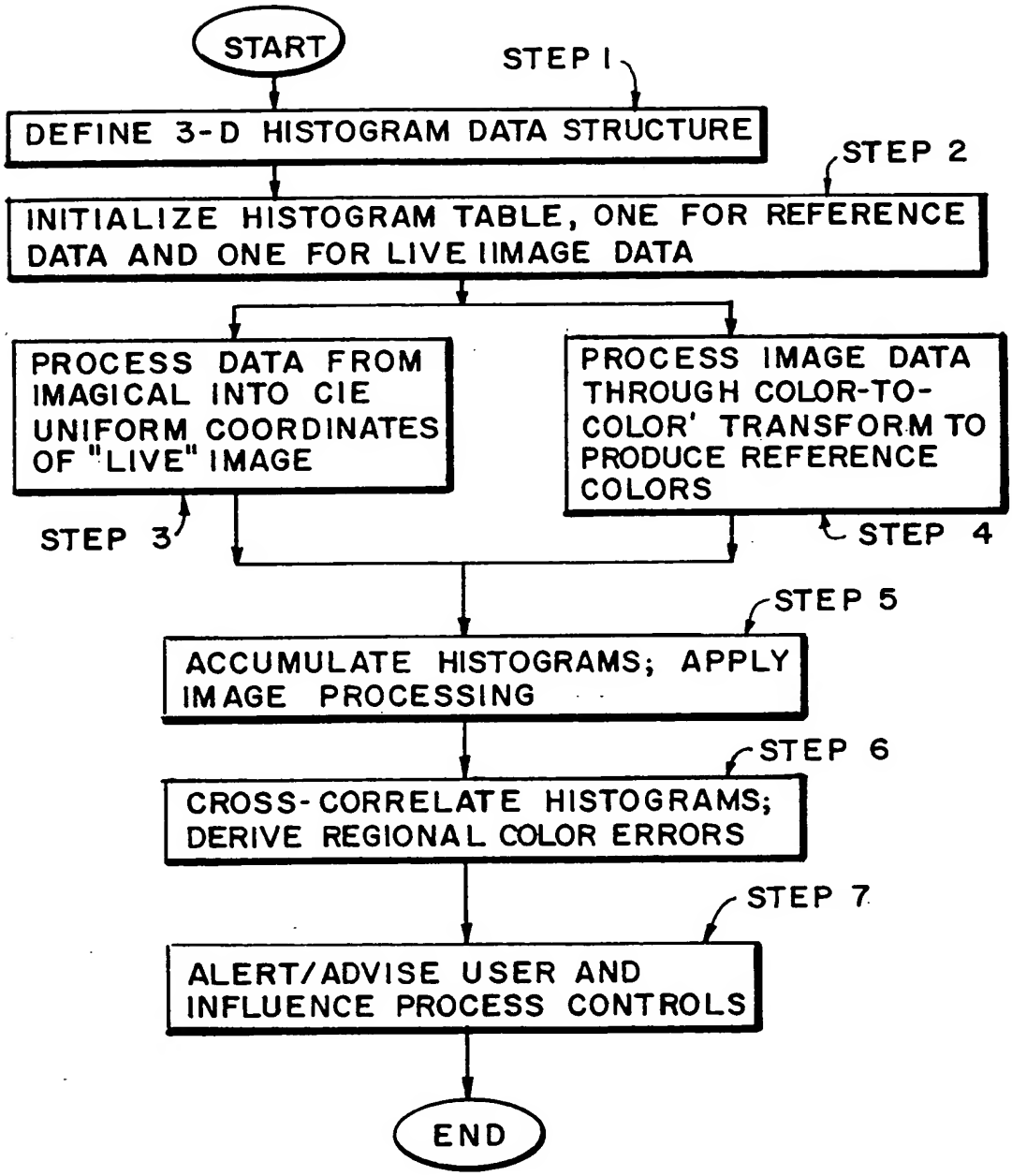

START
STEP 1
DEFINE 3-D HISTOGRAM DATA STRUCTURE
STEP 2
INITIALIZE HISTOGRAM TABLE, ONE FOR REFERENCE DATA AND ONE FOR LIVE IIMAGE DATA
PROCESS DATA FROM IMAGICAL INTO CIE UNIFORM COORDINATES OF "LIVE" IMAGE
PROCESS IMAGE DATA THROUGH COLOR-TO-COLOR' TRANSFORM TO PRODUCE REFERENCE COLORS
STEP 3
STEP 4
STEP 5
ACCUMULATE HISTOGRAMS; APPLY IMAGE PROCESSING
STEP 6
CROSS-CORRELATE HISTOGRAMS; DERIVE REGIONAL COLOR ERRORS
STEP 7
ALERT/ADVISE USER AND INFLUENCE PROCESS CONTROLS
END

FIG. 20

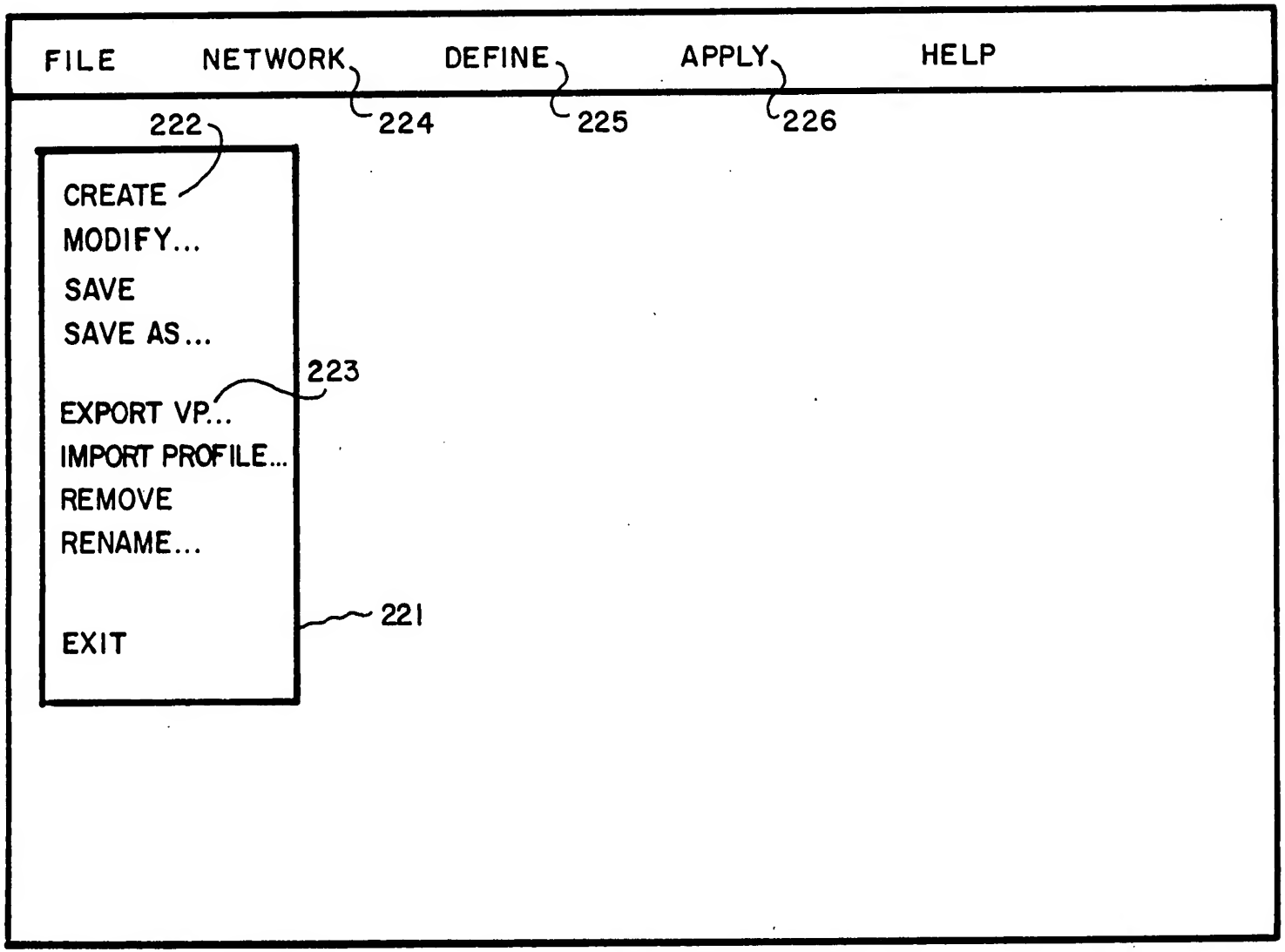

FILE
NETWORK
DEFINE
APPLY
HELP
222
224
225
226
CREATE
MODIFY...
SAVE
SAVE AS...
223
EXPORT VP...
IMPORT PROFILE...
REMOVE
RENAME...
221
EXIT

FIG. 21A

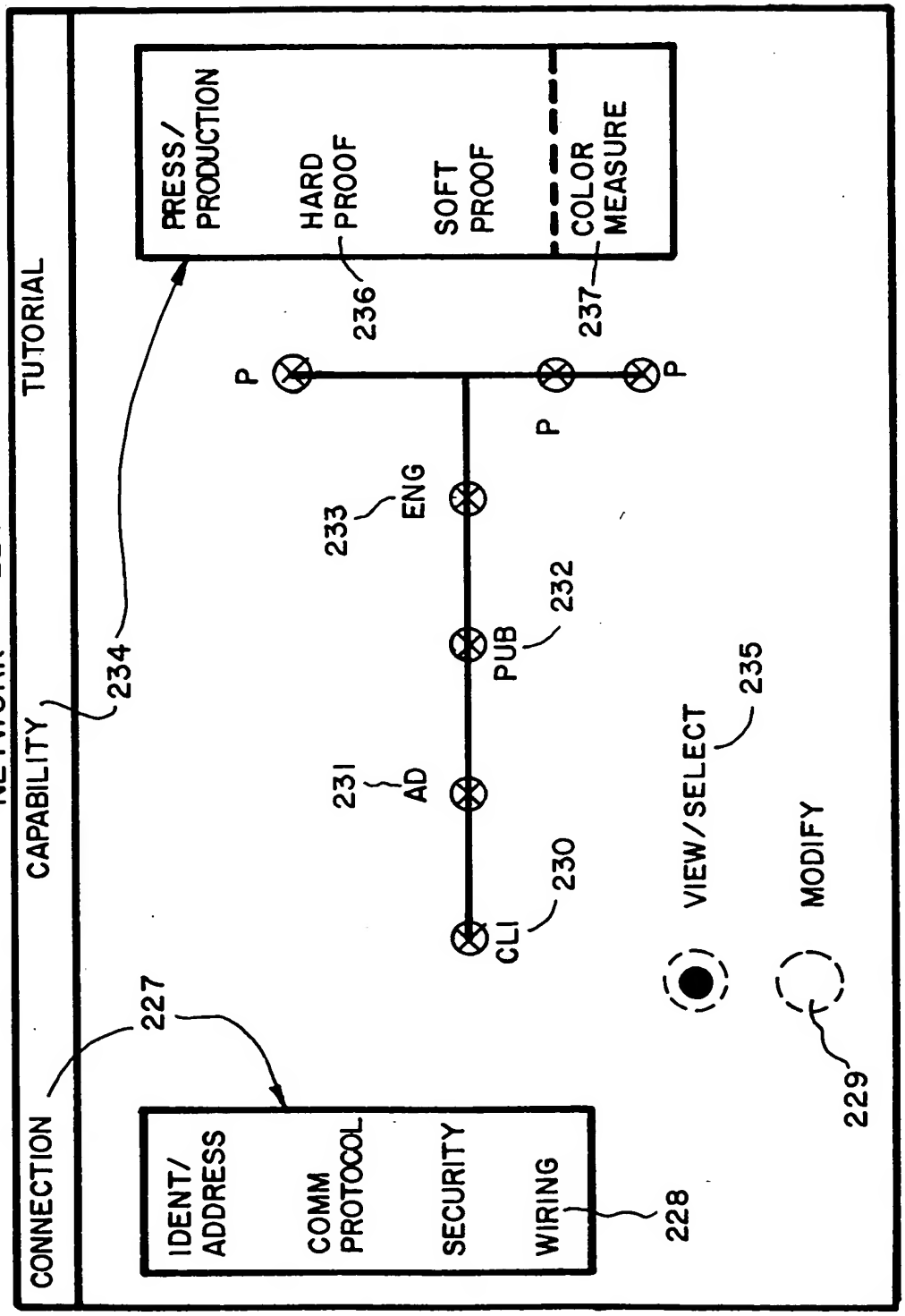

NETWORK
CAPABILITY
224
TUTORIAL
234
PRESS/
PRODUCTION
HARD
PROOF
SOFT
PROOF
COLOR
MEASURE
236
237
P
P
P
233
ENG
232
PUB
231
AD
230
CLI
VIEW/SELECT
235
MODIFY
229
CONNECTION
227
IDENT/
ADDRESS
COMM
PROTOCOL
SECURITY
WIRING
228

FIG. 21B

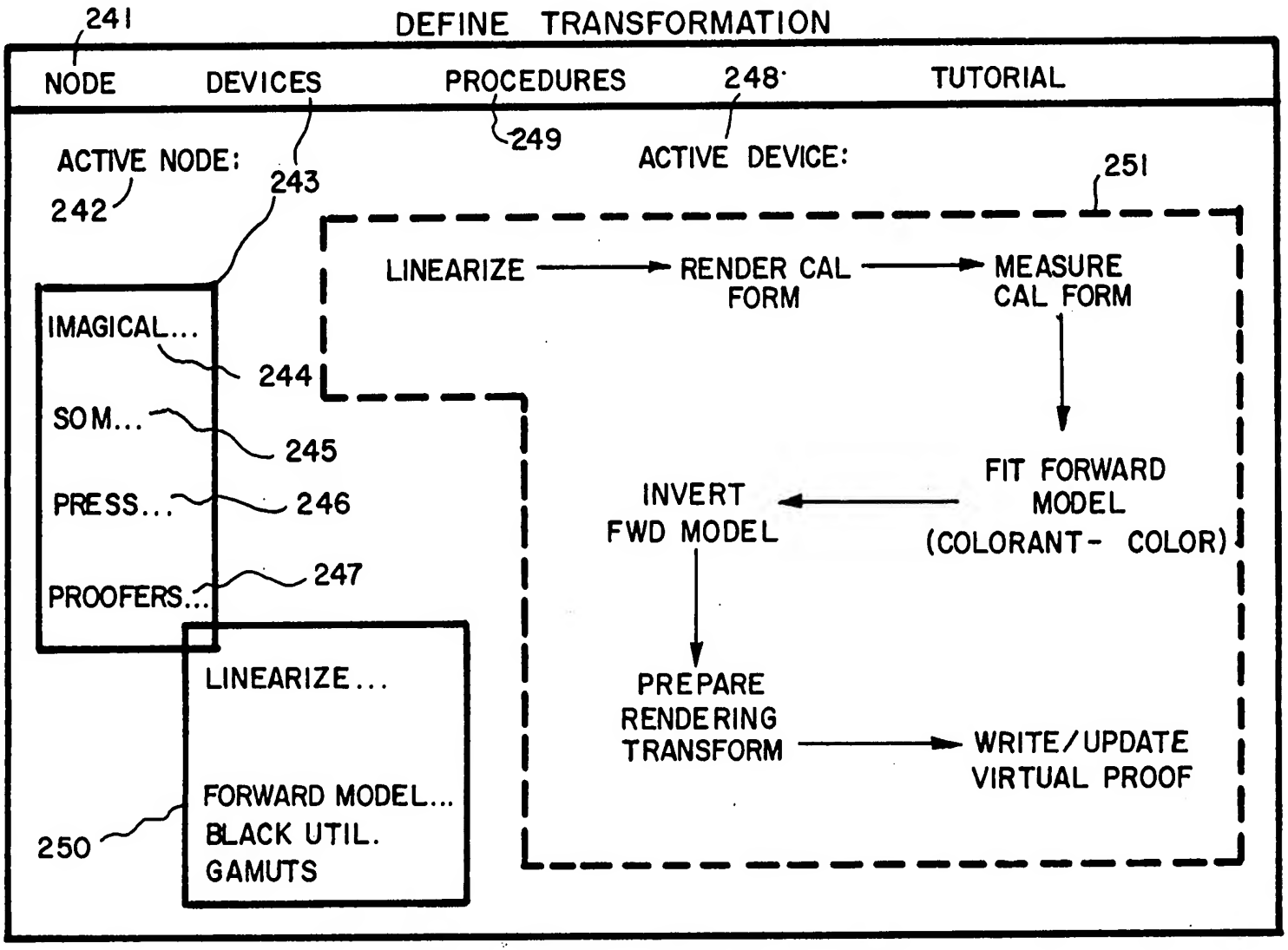

241
DEFINE TRANSFORMATION
NODE
DEVICES
PROCEDURES
248
TUTORIAL
249
ACTIVE NODE:
242
243
ACTIVE DEVICE:
251
LINEARIZE
RENDER CAL FORM
MEASURE CAL FORM
IMAGICAL...
244
SOM...
245
PRESS...
246
PROOFERS...
247
INVERT FWD MODEL
FIT FORWARD MODEL (COLORANT- COLOR)
LINEARIZE...
PREPARE RENDERING TRANSFORM
WRITE/UPDATE VIRTUAL PROOF
FORWARD MODEL...
BLACK UTIL.
GAMUTS
250

FIG. 21C

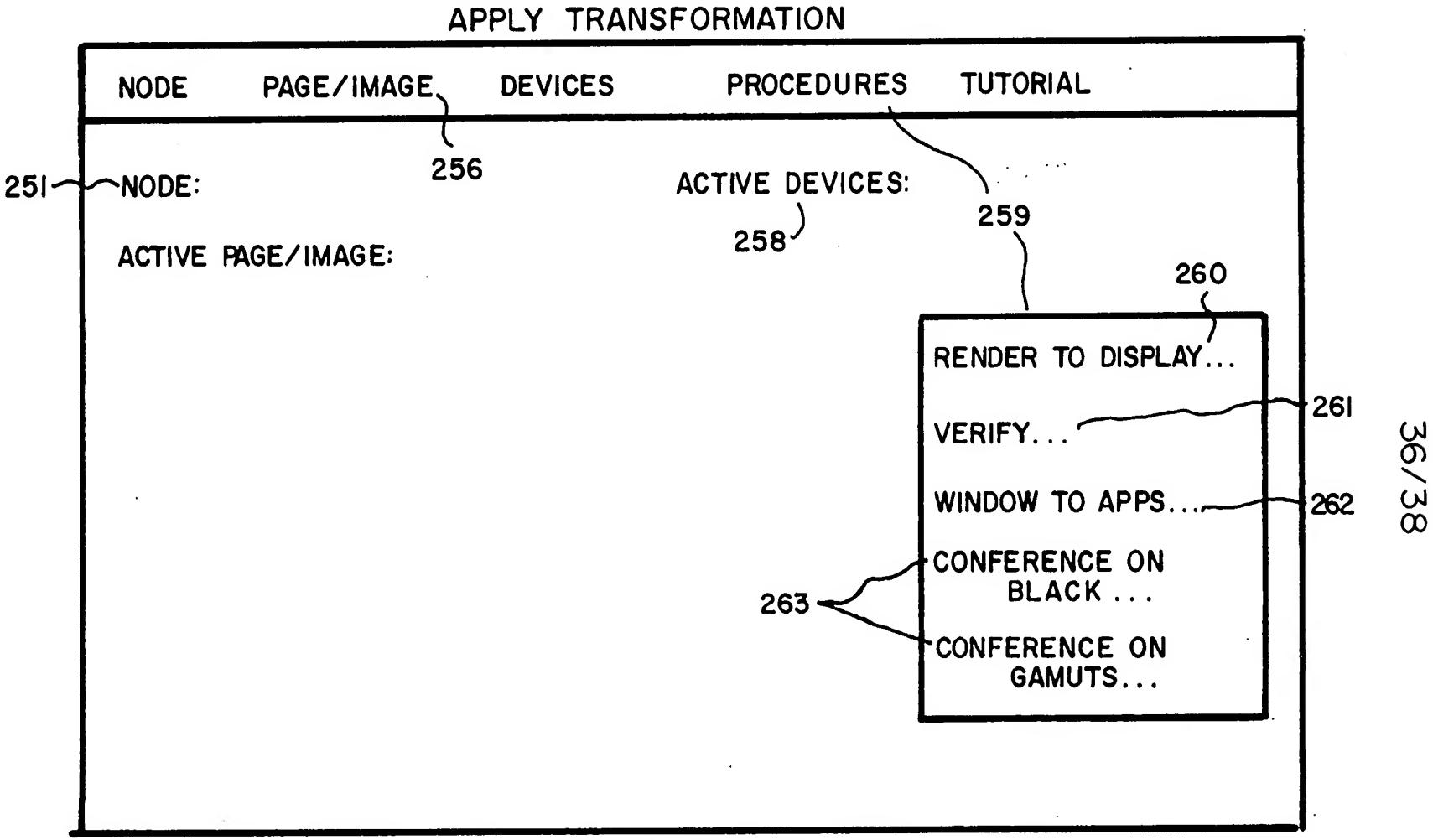

APPLY TRANSFORMATION
NODE
PAGE/IMAGE
DEVICES
PROCEDURES
TUTORIAL
256
251
NODE:
ACTIVE DEVICES:
258
259
ACTIVE PAGE/IMAGE:
260
RENDER TO DISPLAY...
261
VERIFY...
WINDOW TO APPS...
262
263
CONFERENCE ON BLACK ...
CONFERENCE ON GAMUTS...

FIG. 21D

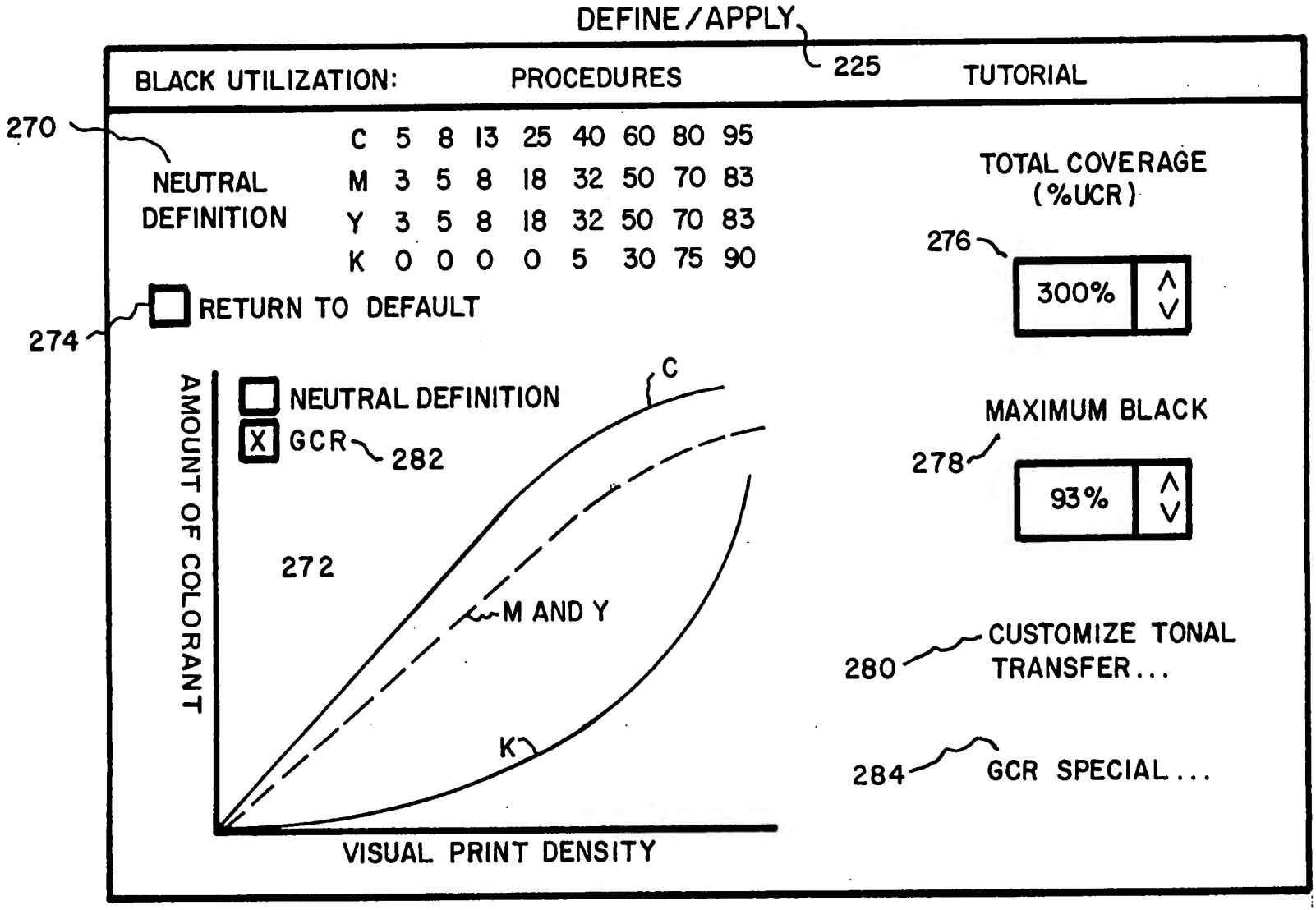

DEFINE/APPLY
225
BLACK UTILIZATION:
PROCEDURES
TUTORIAL
270
NEUTRAL DEFINITION
C 5 8 13 25 40 60 80 95
M 3 5 8 18 32 50 70 83
Y 3 5 8 18 32 50 70 83
K 0 0 0 0 5 30 75 90
274
RETURN TO DEFAULT
TOTAL COVERAGE (%UCR)
276
300%
MAXIMUM BLACK
278
93%
NEUTRAL DEFINITION
GCR
282
272
C
M AND Y
K
AMOUNT OF COLORANT
VISUAL PRINT DENSITY
280
CUSTOMIZE TONAL TRANSFER...
284
GCR SPECIAL...

FIG. 21E

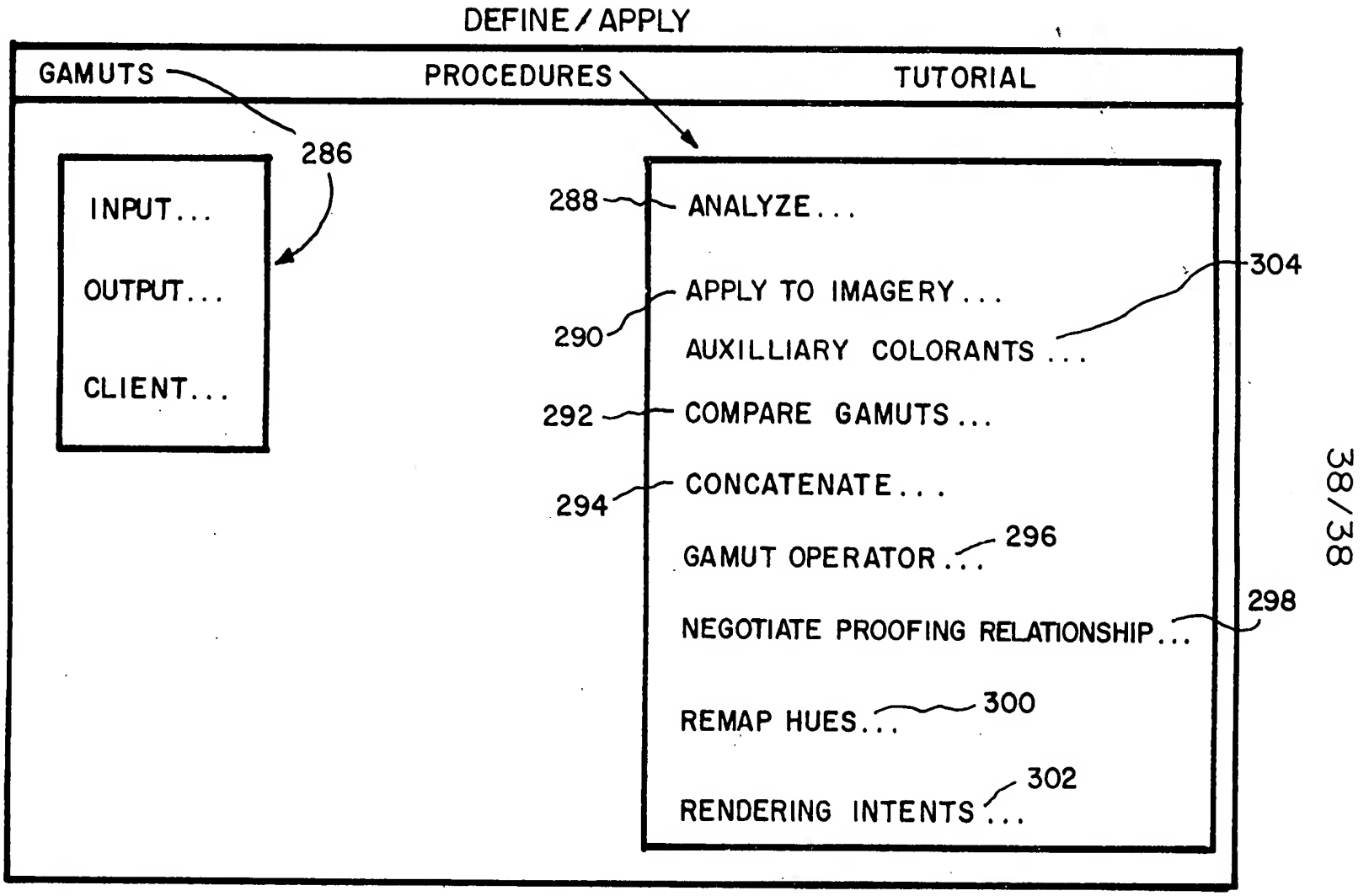

DEFINE / APPLY
GAMUTS
PROCEDURES
TUTORIAL
286
INPUT...
OUTPUT...
CLIENT...
288
ANALYZE...
APPLY TO IMAGERY...
290
AUXILLIARY COLORANTS...
304
292
COMPARE GAMUTS...
294
CONCATENATE...
GAMUT OPERATOR...
296
NEGOTIATE PROOFING RELATIONSHIP...
298
REMAP HUES...
300
RENDERING INTENTS...
302

FIG. 21F